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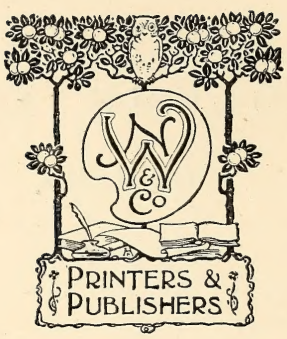
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ANNUAL ADDRESS TO THE MEMBERS

OF THE

SOUTH AFRICAN PHILOSOPHICAL SOCIETY

On August the 17th, 1904.

By the President, J. D. F. GILCHRIST, M.A., Ph.D.

SOME FEATURES OF THE MARINE FAUNA OF SOUTH AFRICA.

Following the example of former Presidents of the Philosophical Society, an example which our esteemed Secretary who has long been associated with the Society assures me has now acquired the authority of a rule, I shall endeavour to lay before you to-night a few of the outstanding features and facts in connection with a subject in which I have been more particularly interested. It is a subject which in the past has not received the amount of attention that its peculiarly interesting character merits, and it would be premature now to formulate any sweeping and definite generalisations which a fuller knowledge of facts will yet make possible. There are, however, certain well-ascertained facts and certain general features which are becoming apparent, and it may not be without interest to present these in the form of a brief summary.

I will draw your attention in the first place to what may be regarded as *the* feature of the Marine Fauna of South Africa, or rather the key to the whole character of this fauna. It would apparently be a wild statement to say that this is intimately associated with the rise and fall of the barometer, but I hope to show you that this is to a large extent the case, and I put it in this way in order to emphasise the special features I wish to bring to your notice.

We know that all forms of animal life are intimately associated with their environment or the environment of their ancestral forms, and we readily understand how in the case of terrestrial animals the physical factors in operation, for instance, in the forest, in the desert, or in arctic regions, demand a strict

conformity to the surrounding conditions, but we do not so readily realise, and I venture to say that even workers in this particular line of investigation do not yet fully realise how intimately and in what way marine life is co-ordinated with its environment, more especially with its purely physical features. This is particularly the case with regard to the pelagic forms, or forms not modified by the varying surroundings of shore life, in which such factors as physical conformity of coast-line, nature of the bottom, presence or absence of vegetable life, &c., play an important part, but forms which are moulded according to the simple varying elements in sea-water. These are, briefly, the comparatively slight variations in the amount of salt contained in solution, and the more marked variation in temperature.

It is to this that I wish in the first place to direct your attention, and in order to do so I will briefly review some of the more important facts which have been ascertained with regard to the physical features of the waters on the South African coast.

You are aware that as a result of the unequal atmospheric pressure there are two great currents of wind—the Trades blowing in an oblique direction from north-east in the northern hemisphere, and from the south-east in the southern hemisphere, and that these give rise to a surface movement of the waters over which they pass so that there is a general movement of the waters from the poles in corresponding directions towards the equator where they meet and flow in a westward direction parallel to each other, forming the great equatorial currents of the northern and southern hemispheres. There are, however, two great continuous land barriers interposed in the course of these currents, Europe, Asia, and Africa forming one, North and South America forming the other. In addition there is another barrier, with gaps, however, viz.: that formed by discontinuous land masses in the meridian of Australia, the East Indies, and China. This third barrier I mention separately for a reason which shall appear later.

The result of the interpolation of these land masses is that the bodies of water thus set in motion and which must find an outlet to maintain the general oceanic equilibrium are directed towards the poles again. This is, of course, most clearly marked in the parts of the Indian, Pacific, and the Atlantic Oceans situated in the southern hemisphere, for there the movements of the waters are less interrupted by land masses, and inasmuch as the Pacific is comparatively shallow, and the movement of the water is there much interrupted by islands and coral reefs, it is in the Indian and South Atlantic Oceans that this phenomenon is best illustrated.

Now there is one striking difference in the course of the two currents in these regions. In the Indian Ocean there is no outlet towards the north, and the whole mass of water is turned down the South African coast, where it is known successively as the Mozambique current, the Natal current, and the Agulhas current. The Southern Atlantic current, on the other hand, is met in its course by the projecting portion of South America, and is split up into a branch which flows to the south along the coast of Brazil, and another which is directed northwards into the Carribean Sea and the Gulf of Mexico, the origin of that great current of the North Atlantic—the Gulf Stream. A connection is thus established between the waters of the temperate regions of the southern and the northern hemispheres.

These are the outstanding features of the circulation of the surface waters of the ocean. There is yet another to be considered before we can be in a position to thoroughly realise the peculiar features of the seas round South Africa. It is found that there is a constant drift of the waters of the southern hemisphere from the pole in an easterly and northerly direction, thus forming a south polar drift current or the west wind drift current, and this mighty current moves between the antarctic circle and the parallel of 45° south round the open waters of the southern seas unimpeded except by the tongues of land projecting into those regions, viz., the continent of South America, that of Africa, and to a less marked degree that of Australia. The continent of South America projects far south beyond the parallel of 50°, consequently a great portion of the current is caught and deflected northwards along its western coast, while the whole of its southern portion is laved by the cold water. In the case of South Africa, however, which is situated in a much lower latitude, a smaller portion of the current is caught and deflected northwards along its western side, and it is not strong enough to completely force back the warm equatorial current which is coming south along its eastern side, though strong enough, however, at times to bring icebergs from the Antarctic to within a short distance of the South African coast.

It will thus readily be seen, then, that the sea round the South African coast exhibits an almost unique character and one of fundamental importance, not only in oceanic circulation but, as I hope to show, in the distribution of marine life. On the one hand it is connected by currents with the seas to the eastwards, directly to the Indian Ocean and indirectly to the Pacific, while on the other it is directly connected to the South Atlantic by the deflected northwards-going branch of the Antarctic drift, and more indirectly to the North

Atlantic, as this branch, as it proceeds northwards, becomes mingled with the return current of the South Atlantic equatorial to form the Benguela Stream which is ultimately carried over, perhaps partly as a cold undercurrent, to the coast of South America, part passing through the Carribean Sea into the North Atlantic.

If then marine pelagic fauna is determined by its environment like other faunas, and if, like other environments, there are great factors within this determining the geographical distribution of the contained forms of life, it will be readily understood that the key to the character of the marine fauna of the Cape is to be ultimately found in the peculiar features of its sea, which have just been enumerated. Before, however, passing on to this, it will be necessary to consider these features in more detail.

Some years ago, in view mainly of the great importance of a knowledge of the currents and changing character of the sea for a determination of the laws which regulate the occurrence migration and habits of fish and other forms of sea-life, a series of temperature observations were begun at about twelve different stations round the coast; and it has been observed that the waters of the east coast differ very considerably in temperature from those of the west coast, and further, that while there is a gradual cooling of the Agulhas current as it proceeds southwards and westwards, there is a very abrupt change between the stations in False Bay and Table Bay, showing that this is the meeting-place of two great bodies of water of different origin.

The details of this transition can be shown by the result of a series of observations of sea temperatures taken for a number of years at the Roman Rock Lighthouse in False Bay, and at Robben Island in Table Bay. The following diagram is drawn up from the data and shows the mean monthly temperature of the respective places for a period of three years. It will be observed that in summer there is a difference of about 6°, while in winter there is a close approximation of the curves of temperature.

Another diagram will show the details of the variation of temperature at points between these two stations at practically the same time. It is drawn up from observations taken every ten minutes on board the *Pieter Faure* when on passage from Table Bay to False Bay. In conjunction with the temperature curve is shown one indicating the variation in salinity of the sea-water.

Another diagram drawn up from a series of observations made by the mail steamer between Cape Town and Cape Hanklip illustrates the same phenomenon.

I draw your particular attention to this variation in temperature

conjoined with a corresponding variation in salinity as indicating that the cold waters of the west coast of the Cape are not merely the welling up of the colder waters when the warmer upper layers are driven away from the shore by winds; no doubt much of the variation in temperature can be brought about by such an agency, but this very marked difference of temperature and salinity can most satisfactorily be explained by the close proximity of the southern drift current.

The chart which I now show indicating the course of drift bottles and the following section of the sea off the west coast of the Cape Peninsula proves further that a small branch of the Agulhas current, occasionally at least, escapes round Cape Point towards the west coast.

Having outlined the main physical features of South African waters as they are modified by the great ocean currents which meet in this region, let us consider briefly some of the more local peculiarities which are also important features in the moulding of the character of the South African marine fauna. The feature of the South African coast is its want of bays, natural harbours, or inlets, and of any islands or large fresh-water inlets, all of which in some other countries give rise to peculiar modifications of sea-life. Although, however, there is not a single large river which does not admit the sea for several miles inland, all are capable of swelling into floods of great volume, bringing down with them, to be deposited on the sea bottom, much mud and *débris* of all sorts. Thus it has been found that there are extensive areas of mud in St. Helena Bay into which the Berg River opens, at St. Sebastian Bay near the mouth of the Breede River, at Mossel Bay near the mouth of the Gouritz River, and at Bird Island near the Sundays River. Another feature of the sea bottom is a deposit of a totally different character and origin. It has been found on the west coast from St. Helena Bay to Cape Point, and from thence over the western side of the Agulhas bank, but not beyond on the eastern side of the bank, nor on the eastern side of South Africa. This is a kind of green mud or sand, apparently of organic origin.

Such are the leading features of the environment of the marine fauna. We may now proceed to consider briefly, and by means of a few examples the co-ordinate modifications found in the forms of animal life themselves. In the trawling operations of the Government steamer exceptional opportunity was afforded of obtaining information as to the kind and distribution of the flat fishes which are in our waters, and to these we shall first direct attention. Trawling operations were first commenced

on the west coast, and it was found that in a stretch of ground between Dassen Island and Saldanha Bay a valuable species of Sole (*Synaptura microlepis*) occurred. On proceeding further north the same Sole was found, some of the specimens being of a remarkably large size, several of them weighing about 9 lbs. In neither of these places, however, did it occur in great abundance. Another species of flat fish was found near Dassen Island (*Cynoglossus capensis*), but only occasionally. On extending operations to False Bay it was found that the first mentioned was not to be found, while the second was in fair abundance. Further to the east another species (*Synaptura pectoralis*) was found in great abundance—in such abundance that it now forms the chief item in the catch of three large trawlers which shortly afterwards commenced operations in this area. The same Sole was found in abundance on a large area of mud near Bird Island, and at a spot several miles beyond East London. The attention of the Natal Government was attracted by these results (a Natal trawler was the first on the new ground after its discovery), and at their request the Cape Government surveyed the coast for trawling ground. There, however, an entirely different state of things prevailed. Suitable ground, with a deposit of fine mud, was indeed found off the Tugela River, and several new species of flat fish were discovered, but all of a small size. There was no trace whatever of the Sole so abundant on the east and south coasts of Cape Colony. Another example from the group of the fishes illustrates just as forcibly the effect of the different conditions to be found on the east and west coasts of South Africa. This is the Snoek (*Thrysites atun*), which, being of great commercial importance, is better known than most of the other fishes with respect to its places of occurrence and relative abundance. It is a migratory fish, and during the season appears in immense shoals on the west coast (though of recent years somewhat scarcer, there is evidence of late that it is again reappearing in the same abundance in some places). It is known to occur as far north as Sandwich Harbour, which was at one time open to fishing boats, though now inaccessible through accumulation of sand. Here a fishing station was at one time established for the special purpose of Snoek fishing. It is found further south in the neighbourhood of St. Helena and Saldanha Bay, where also a fishery has been carried on for many years, and a large export trade to Mauritius and other places carried on. In Table Bay it is not so abundant, though at one time it was found in almost incredible numbers. In False Bay it is less seldom seen, though in good fishing seasons it occurs very abundantly. Further to the east the supply falls off rapidly. It has, however, occasionally been

known to visit Mossel Bay. There is no record of its having ever been seen at Algoa Bay, and it is quite unknown on the east coast. Its distribution is therefore intimately associated with the colder waters of the west coast. It is indeed probable that some light might be thrown on its relative abundance or scarcity at different periods by a more intimate knowledge of the temperature conditions prevailing in different years. Another example, from the group of the Crustacea, illustrates perhaps even more forcibly than the last two the effect of the changing environment we meet in passing round the South African coast; this is the large Crawfish (*Palinurus lalandii*). This Crustacean occurs in such quantities in Table Bay that the supply was sufficient to keep a large canning factory going. The supply seems practically inexhaustible. It is found in the same abundance northwards beyond Angra Pequena. It occurs also in quantity in Hout Bay, but not commonly in False Bay. The samples I have seen from this region are much smaller in size, and the same is to be said of those procured further east, at Hermanus. They are undoubtedly the same species, but smaller. There is yet no record of their occurrence to the east of this locality, and a different species has been found at Mossel Bay, this also in its turn seems to be absent from the Natal coast, where still another and much smaller species is found, and where also the Crustacean fauna shows a considerable increase in species as compared with that of the west and south coasts.

Such instances could be easily multiplied, but these are sufficient to indicate the general tendency. One other example, however, may be mentioned as illustrating the same feature in a reverse way, viz., the pearl oyster *Avicula*. Its first definite appearance is on the south coast, just beyond Cape Agulhas. Specimens hitherto found, however, have been so small as to be of little commercial importance. It seems to occur all along the south coast from this point. It is found on the east coast as far as the Mozambique Channel, where it is larger and more abundant.

We see, therefore, that the different physical conditions on the east and west coasts are reflected in the character of the fauna, the general rule seeming to be that in the colder waters the species are fewer, the individuals more numerous, while the warm waters are characterised by greater variety of species and fewer individuals of any one species. In some of the cases cited the cold-water forms grow to a much larger size than in others the warm-water forms.

Having noted the variety in the fauna as illustrated by a few species, we naturally look about for some explanation. It might

at once be assumed that this is due to the different character of the waters. We will find, however, as for instance in the last-mentioned feature, that this is far from sufficient. A key to a fuller illustration is found when we consider the general distribution of this marine fauna, and the affinities of its component elements to the general marine fauna of the globe. For this purpose we will now direct attention more to the distribution of the strictly pelagic or oceanic forms. One of the most obvious instances is found in the general distribution of the Snoek (*Thyrsites atun*) which we have already taken to illustrate another point. It is found in abundance on the Chilian coast of South America, at Tristan d'Acunha, on the west coast of South Africa, and on the west coast of Australia—that is, on those coasts on which the Antarctic drift current impinges. It is therefore a form which is characteristic of the west wind current. There are other forms of the South African fish fauna such as the general *Bdellostoma*, *Agriopus*, *Callorhynchus*, which link it on to the regions traversed by this current, and those general in South African waters, like the Snoek, seem to be most characteristic of the west and south coast. On the other hand, there are a number of forms growing more numerous towards the west which show a great affinity with the warmer waters of the Indian Ocean. Thus the well-known Blaasop (*Tetrodon honckenii*) is a representative of the tropical Gymnodonts. It is found in abundance in False Bay, but seldom in Table Bay, though it is found in Hout Bay. One or two other members of the group are occasionally found in False Bay, and they become much more abundant towards the east coast. There also such forms as *Pterois*, *Apistus*, &c., have been found, while the Squamipinnes increase in numbers and species. The same fact is illustrated in the flat fishes.

The affinity with tropical Indian Ocean forms is, like the previous case, readily understood by the intimate connection with that region brought about by the warm current of the east coast, and we are not surprised to find that regions of the same latitude on the west coast are entirely devoid of these forms. When, however, we find in the Cape seas *Zeus japonicus* and *Monocentris japonicus*, forms characteristic of Japanese waters, it is more difficult to realise that the distribution can be accounted for by currents connecting the two regions, though I would again remind you that there are no insuperable land barriers between the Indo-Pacific coast and that of South Africa. There is, however, another element in the South African marine fauna much more difficult to account for, and one which, from evidence now accumulating, seems to be a

characteristic feature. This is the presence of forms specifically identical with some that occur in European waters. Such anomalies of distribution are not rare. For instance, Günther has drawn attention to the fact that several of the genera, and even species, in Japanese waters are identical with Mediterranean forms, and similarly, Alcock has shown that the same phenomenon occurs in the Indian Seas. To account for the first case Günther has advanced the hypothesis that at some time in the geological history of continents there was a direct sea communication between Japan and the Mediterranean, and Alcock has had recourse to the same convenient and indeed not improbable explanation. The familiar Stock-fish (*Merlucius vulgaris*) and the Maasbanker (*Caranx trachurus*) are examples from the group of the fishes illustrating identity of Cape and European forms, and several other species recently found in South African waters have proved to be identical. Even in the group of marine annelids and other invertebrates the same agreement has been observed. In the fishes the affinity to the Mediterranean forms has been specially noted. In drawing attention to the similarity of the Japanese and Mediterranean forms Günther has given a list of Japanese shore fishes of which fifty-four genera are identical in both places; of these thirty-five have now been found at the Cape, where also three genera, described in the list as peculiar to Japanese waters, have been found. How is the presence of Mediterranean forms in South Africa to be accounted for? Unfortunately we cannot have recourse to an explanation that would postulate a former direct communication in past geological times, elastic as such explanations are, and we are compelled to look about for further information with regard to the existing means of distribution. I have said "unfortunately"; perhaps, however, further necessary search for facts will in the long run lead to a truer solution. As you will have observed, the direction in which the solution may be looked for is in a more intimate knowledge of the connection between the waters of the North and South Atlantic, and it is in this direction also that we must first look for a solution of the much greater but cognate problem of bipolarity, or the identity of Arctic and Antarctic forms, and that, only after looking most carefully into the specific diagnoses of authors.

I have, however, wandered further than I intended into this fascinating question of distribution, and have said enough to direct your attention to the composite character of the South African marine fauna. I will only mention two other cases which seem to be of special interest. A certain Lamellibranch

occurs in comparatively shallow water in Iceland; it has also been found in deep waters near the Equator, and recently in comparatively shallow waters in South Africa. Still more instructive in this respect are the results of a recent examination of the different species of Copepoda met with in South African waters. It has been shown that of the species found south and west of Cape Colony a considerable number occur also in the northern hemisphere. Professor Cleve, who made this discovery, finds in it a confirmation of his hypothesis that the waters of the temperate Atlantic in the Northern Hemisphere originate not in the Gulf Stream but in the Benguela current, which is supposed to pass as an under-current below the waters of the tropical Atlantic.

I will now return to a subject I just touched upon previously, viz., the occurrence of a peculiar deposit, commonly known as green sand or mud, which, as recent soundings have shown, occurs very extensively over the bed of the sea, off the south and west coast of the Cape. A constituent has been found to be phosphate of lime which coats the coarse grain of sand inshore, and in deep water where these terrigenous deposits are absent, it is found encrusting and filling up the shells of Foraminifera and other characteristic deep-sea deposits. It also is often found as nodules formed round a central nucleus. It is therefore a formation of comparatively recent date, and can hardly be derived from the common mineralogical form — apatite — which is found in volcanic rocks. It might be thought to be derived from submarine mineral springs, but its great extent is against such a supposition. Finally it might be derived from the phosphates found in sea-water, but the small quantity thus found and the mode of its occurrence are against this. The distinguished oceanographer, Sir John Murray, has devoted particular attention to this problem, and he suggested that it is derived from the phosphate of lime stored up in the living organisms (specially in their bony tissue) which inhabit the sea. He has observed that these deposits of green mud or sand are characteristic of the regions where currents of different character meet, and suggests that it is there that a great mortality amongst sea animals may occur. It is of course difficult to procure direct evidence on such a point, but some recent occurrences in South African waters, and others of an older date, which have come to light, appear to confirm this supposition in a remarkable manner. I hope to give a detailed account of these on another occasion, and only mention some of the main facts now. Some months ago the captain of the trawler which started fishing operations recently on the Agulhas bank was startled to find one day that instead of fresh

fish he hauled on board a net full of dead fish in an advanced stage of decomposition. There are traditions of extreme mortality among the fish in the neighbourhood of Table Bay and on the west and south coasts. If the interpretation, then, of these facts be correct, the deposit of green mud is to be regarded as an ocean graveyard and constitutes another striking feature of the sea and sea-life in South African waters.

I have endeavoured to present the outstanding features of the South Africa marine fauna. It will have become apparent to you that for an adequate solution of the scientific and practical problems connected therewith, due consideration must be given to its peculiar environment, by which it is linked on to the two great oceans of the world, the Indo-Pacific and the Atlantic, as well as to the Antarctic. The most outstanding problems are those connected with the distribution of its diverse forms of life, and you will have seen that these are as yet vaguely defined and understood. I am confident, however, that further research will afford a basis for valid conclusions of both a scientific and practical value.

If I were to attempt to sum up the general aspect of the subject in one sentence, I should say that, as the Cape of Good Hope has been and always will be the main natural highway between the East and West, and is consequently characterised by the possession of a cosmopolitan population, in itself the result of incursions from the most diverse races, so the sea surrounding its coasts for the same reason, viz., its geographical position, is characterised by forms of life from the most remote regions—from the North Atlantic, the Antarctic, and the Indian Ocean, and even an element from the Far East.

Ordinary Monthly Meeting.

July 29, 1903.

Sir David Gill, K.C.B., President, in the Chair.

The Minutes of the last meeting were read and confirmed.

The following nomination was made: Mr. J. Wood, from East London, by Sir David Gill and L. Péringuey.

Dr. G. B. Douglas MacDonald, Professor H. H. W. Pearson, and Mr. W. R. Caley were elected ordinary members of the Society.

Mr. E. H. L. Schwarz showed some specimens of crushed and indented boulders taken by him from the conglomerates belonging to the Uitenhage series in the Division of Uniondale. They were illustrative of the paper he read before the Society during the early part of the year dealing with certain structures produced by crushing in the rocks of Cape Colony.

Mr. Schwarz also exhibited some fossil plants found by Messrs. A. W. Rogers and A. L. du Toit in the Beaufort, Ecca, and Wittenberg beds in the west of the Colony. *Schizoneura africana* Feistm., first discovered by A. G. Bain, and figured by Sir J. D. Hooker, but of which no well-preserved specimens have been found for many years, was met with at Bain's original locality, the Great Fish River, in the Roggeveld. The other specimens were a well-preserved *Phyllotheca* from the Ecca beds of Olivier's Berg, and a Lepidodendroid plant, allied to *Cyclostigma*, from the Witteberg beds of Elands Vley.

Mr. C. M. Stewart read "A Note on the Quantities Given in Dr. Marloth's Paper on the Moisture Deposited from the South-east Clouds," which was followed by a long discussion.

Annual General Meeting.

September 9, 1903.

The President, Sir David Gill, K.C.B., in the Chair.

The Secretary read the General Report for the year ended June 30, 1903.

The Treasurer read a statement showing a balance of £330 17s. 2d.

The Draft of a proposed Royal Charter for the Incorporation of the Society, and Amended Bye-laws, were submitted for the

approval of the Meeting, and duly approved of by the members present.

Dr. J. D. F. Gilchrist was elected President, and Messrs. J. C. Beattie, L. Péringuey, W. F. Purcell, and W. L. Sclater elected Members of the Council for two years.

The Annual Meeting then resolved into an Ordinary Meeting. Sir David Gill exhibited some Radium, and make remarks on the property of the newly-discovered substance.

General Report and Statements for the Year ended June 30, 1903.

COUNCIL.

Sir David Gill, K.C.B., F.R.S., *President.*
L. Péringuey, F.Z.S., *Vice-President, Hon. Secretary.*
J. C. Beattie, D.Sc., F.R.S.E.
G. M. Clark, A.M.I.C.E.
L. Crawford, M.A., D.Sc.
J. D. F. Gilchrist, M.A., Ph.D.
R. Marloth, M.A., Ph.D.
T. Muir, C.M.G., F.R.S., LL.D.
W. L. Sclater, M.A., F.Z.S., *Hon. Treasurer.*

Nine ordinary meetings and one general meeting have been held during the year. At these meetings the following papers were read:—

"Observations of Atmospheric Electricity at Cape Town," by W. H. Logeman.

"On an Almost Perfect Skull of a New Primitive Theriodont (*Lycosuchus vanderrieti*)," by R. Brown.

"The Geological History of the Gouritz River System," by A. W. Rogers.

"On the Deformation of Rocks, Illustrated Experimentally by Crushed Pebbles," by E. H. L. Schwarz.

"Results of Experiments on Table Mountain for Ascertaining the Amount of Moisture Deposited from the South-east Clouds," by R. Marloth.

"Some Notes on Work Done in South Africa in the Department of Astronomy and Geodesy," by Sir David Gill (*Presidential Address*).

Three members have resigned during the year, six have been struck off for arrears of subscription of several years' standing,

The Acting Hon. Treasurer in Account with the South African Philosophical Society, July 1, 1902, to June 30, 1903.

Receipts.

	£	s.	d.	£	s.	d.
To Balance in Bank, on fixed deposit at 3½ per cent.	300	0	0			
,, Floating Balance in Bank	156	7	2			
,, Cash in hand paid into Bank after June 30, 1902	25	9	8			
,, Petty Cash Balance	1	3	0			
				482	19	10
,, Subscriptions—						
3 Full Subscriptions, Town, 1901	6	0	0			
2 ,, ,, Country, 1901	2	0	0			
28 ,, ,, Town, 1902	56	0	0			
12 ,, ,, Country, 1902	12	0	0			
86 ,, ,, Town, 1903	172	0	0			
52 ,, ,, Country, 1903	52	0	0			
2 ,, ,, Country, 1904	2	0	0			
Fractional Subscriptions of New Members and Odd Shillings Sent to Cover Exchange, &c.	11	10	6			
				313	10	6
,, Interest on Money at fixed deposit	10	10	0			
,, 40 Subscriptions to Anniversary Dinner	60	0	0			
,, Government Grant for 1902	100	0	0			
,, Sale of Society's Publications	57	6	3			
,, Sale of Publications of South African Museum to a Member	0	11	0			
				228	7	3
				£1,024	17	7

Expenditure.

		£	s.	d.
By Publications—				
Messrs. West, Newman & Co., for printing—				
Vol. XI., pt. 4	£151 17 6			
Vol. XII., pt. 2	132 8 0			
Vol. XIV., pts. 1 and 2 on account	125 0 0			
,, M. Dujardin for printing two plates, Vol. XIII.	7 0 9			
		416	6	3
,, Local Printing and Typewriting of Notices and Stationery		41	11	0
,, Freight on Publications		15	14	5
,, Rent for Library (April, 1902, to June, 1903)		45	0	0
,, Library Attendant and Caretaker (Jan. to Dec., 1902)		5	0	0
,, Clerical Assistance (T. D. Butler, April to March, 1903)		4	0	0
,, Anniversary Dinner		65	0	0
,, Bronze Tablet to Abbé de la Caille		35	0	0
,, Conversazione to South African Assoc. for Advancement of Science		17	5	6
,, Compilation of International Catalogue of Scientific Literature		10	0	0
,, Postage Stamps		35	4	2
,, Cab and Railway Fares		0	17	3
,, Telegrams		0	2	6
,, Repairs to Ballot Box		0	10	3
,, Refund to South African Museum for Annals sold to a Member		0	11	0
,, Bank Charges		1	18	1
		£694	0	5
,, Balance in Bank on fixed deposit at 3½ per cent.	£300 0 0			
,, Floating Balance in Bank	27 3 3			
,, Petty Cash Balance	3 13 11			
		330	17	2
		£1,024	17	7

(Signed) W. F. Purcell, *Acting Hon. Treasurer.*

We the undersigned, members of the South African Philosophical Society, hereby declare that we have examined the above account, compared the receipts with the counterfoils of the Receipt Book, the cash payments with the Vouchers, and the balance with the Bank Cash Book, and have found the same correct.

(Signed) A. W. Rogers, E. H. L. Schwarz, *Auditors.*

and twenty-four have been elected. The number on the Roll is now 215 ordinary and 4 honorary members—the highest yet obtained.

The Society celebrated the semi-jubilee year of the Society and also the erection of a Memorial Tablet of La Caille by a public banquet, and the members of the South African Association for the Advancement of Science were welcomed at a conversazione, held at the conclusion of one of the ordinary monthly meetings.

Part 4 of vol. xi., parts 2 and 3 of vol. xii., and parts 1 and 2 of vol. xiv., in all 925 pages, have been published and distributed during the year; parts 3 and 4 of vol. xiv. are in the hands of the printers, and are expected at an early date.

The report of the Treasurer shows a credit balance of £330 17s. 2d., but heavy payments are anticipated during the forthcoming financial year.

Ordinary Monthly Meeting.

October 28, 1903.

Dr. J. D. F. Gilchrist, President, in the Chair.

The following nominations were made: Messrs. A. Brink, Kimberley, by J. R. Sutton and L. Péringuey; A. H. T. Muller, Willowmore, by E. H. L. Schwarz and L. Péringuey; J. S. Thomson, by J. D. F. Gilchrist and L. Péringuey.

Messrs. R. J. A. Innes, G. Mann, and Dr. Wessels were elected ordinary members.

Dr. Gilchrist exhibited a series of specimens showing various stages in the development of a fish *Scombresox* from the egg to the adult form. The egg differed in some respects from that described as belonging to the European *Scombresox saurus* which is recorded from the Cape. The most notable feature was the absence of the filaments, their place being taken by what appeared to be small dark dots. A huge crab, *Lithodes Antarcticus*, was also exhibited. The specimen was obtained at a depth of 600 fathoms in a region about 30 miles off Cape Point. It showed the typical red colour of many deep-sea animals, and also the absence of carbonate of lime deposit, as indicated by the soft external shell.

Mr. J. Stuart Thomson, F.L.S., read a paper on "The Periodic Growth of Scales in Gadidæ as an index of Age."

The chief contention of this paper was that scales of certain species of Gadidæ show a series of parallel eccentric lines which

indicate successive increments of growth. These lines of growth have been found to be more widely separated in that part of the scale formed during the warm season of the year than in the portion formed during the cold season. The alternation of the two series gives rise to the appearance of rings which the author maintains to be annual, and these would thus indicate the age of the fish in years. By means of a series of lantern slides from photo-micrographs, Mr. Thomson illustrated his hypothesis by demonstrating these rings in scales from several species of Gadidæ. Owing to the statistical nature of this research only a summary was read. The complete paper will be published in the Journal of the Marine Biological Association, Plymouth, 1903.

Ordinary Monthly Meeting.

December 29, 1903.

Dr. J. D. F. Gilchrist, President, in the Chair.

The members of the Medical Congress attended by special invitation.

Present: 110 members and visitors.

Messrs. A. Brink, A. H. T. Muller, and J. S. Thomson were elected ordinary members.

Professor Payne was nominated as ordinary member by Professor Logeman and Dr. Marloth.

The abstract of a paper, "An Introduction to the Study of South African Rainfall," by Mr. J. R. Sutton, and two papers by Dr. Thos. Muir, *i.e.*, "Factorizable Continuants" and "Developments of a Pfaffian," were taken as read.

The first paper is the fifth of the series planned some years ago to describe the meteorology of the South African Tableland in a form suitable to the requirements of the physicist. It gives a history of Kimberley rainfall from 1877–1902, and discusses the annual, monthly, daily, and hourly quantities, both statistically and by the harmonic analysis.

The greatest known annual fall at Kimberley is $34\frac{1}{4}$ inches in 1891, the least $8\frac{3}{4}$ inches in 1897. This range is less than that of similarly situated places in Australia and India, but greater than that of South America. The greatest fall in 24 hours occurred in September, 1902, and amounted to more than $4\frac{1}{2}$ inches. The wettest time of the year is during the last week of February, the

driest during the first week of August. October is remarkable for the great number of days upon which the fall has been between ½ inch and 1 inch; and there is only one day on record upon which the fall exceeded 1 inch. On the other hand, if it rains in September it pours, so that 58 per cent. of the total September fall in 26 years has come in seven days. Again, there is only one October known in which the month's rain exceeded 2 inches, and only one known without any rain at all.

The hourly variation of rainfall gives a curve which is nearly the inverse of the barometric oscillation, and is closely connected with the dew-point curve. Upon the whole, rather more rain falls by night than by day; but since the number of hours of rain is much greater by night than by day, it follows that the rate of fall is heavier by day.

The harmonic constants of rainfall, pressure, and vapour-tension are also related to each other. Like the semi-diurnal wave of pressure, the semi-diurnal wave of rainfall frequency varies very little in point of time through the year. The constants for thunderstorms bear a strong family likeness to those of rain. In the paper they are compared with the constants for Basle and Vienna.

Comparing the rainfall with the Kimberley wind-system, it appears that in any month when the rain is abundant the usual prevailing wind of that month prevails yet more, or, in other words, the rain decreases as the vane shifts from its normal position.

The temperature of the falling rain is referred to, and the approximate altitude of the clouds at different times in the day and month computed from the known dew-point. It appears that the clouds float at a lower level in the more cloudy months, and that in any month the average altitude of the first plane of condensation will be greater as the cloudiness of the sky is less.

The position of Kimberley in the general scheme of South African rainfall is considered by comparing together the rainfall of 160 stations in the country having records of 15 to 20 years or so. Monthly and annual averages are determined for these, both for the separate stations and also for the various areas into which the Meteorological Commission has divided South Africa. Approximate harmonic constants are computed for each area, in terms of the monthly averages, and also for a selected number of the separate stations. The wettest place known in South Africa is probably Maclear's Beacon, on Table Mountain, with an annual average approaching, perhaps, 87 inches. Other wet places are Ceres, Lower Katberg, Hogsback, Evelyn Valley, and parts of Natal, with average falls of 40–60 inches a year. Port Nolloth is one of the

driest places, with an annual average of $2\frac{1}{2}$ inches, Pella being close up with $3\frac{1}{4}$.

A lengthy discussion of the harmonic elicits some interesting conclusions with regard to the laws obeyed by the rainfall of the country. It seems to follow from this that the rainfall of Natal is more nearly related to that of the country lying between Cape Agulhas and Mossel Bay than it is to that of the Port Elizabeth area.

Rain on the central tableland comes chiefly with a N.E. wind and a falling barometer; on the coast of Natal with a S.W. wind and a rising barometer. In this and other respects there is scarcely any special agreement between the rain conditions of the two areas.

The cloud statistics of a number of places are discussed as far as the quality of the results justifies. There seems not to be so close a connection between cloud and rainfall as might have been expected.

The author's final conclusion is that the rain of Central South Africa originates in the main in the doldrums, being reinforced more or less by the moisture evaporated from the Indian Ocean; and that the aridity of the west coast is not caused, as Buchan asserts, by the southern anticyclone belt, but simply by the coldness of the water.

Dr. R. Broom gave an account of the evolution of the mammalian shoulder girdle in the light of recent researches in South African palæontology.

The Labyrinthodont type of girdle, which may be taken as ancestral to all the later types, was shown to consist of the three cartilaginous elements—scapula, coracoid, and precoracoid, but of which only the scapula is usually ossified, with, in addition, five membrane bones—a median interclavicle, two large flat clavicles, and two slender supraclavicles or cleithra.

In Pareiasaurus and in Dicynodon the same 11 elements are still found, and all ossified. The scapula is well developed, and has a distinct acromion process.

In the Theriodonts the cleithrum appears to be lost.

The Monotreme shoulder girdle differs from that of the Dicynodonts in the loss of the cleithrum and in the reduction of the precoracoid.

In the fœtal Marsupial there is still a well-developed coracoid which articulates with the sternum, and the precoracoid is possibly represented by the coraco-clavicular ligament. At an early stage

the coracoid becomes detached, and degenerates into the coracoid process of the adult.

The lecture was illustrated by a series of diagrams representing the various stages in the evolution.

Mr. W. L. Sclater gave an address on the "Snakes of South Africa," with special reference to the poisonous species.

After some remarks on the classification and structure of the Order Ophidia in general, a list of the poisonous species more commonly met with was given with a few notes on their habits and distribution.

The lecturer concluded with some account of the recent work in connection with snake venom and its antidotes, specially associated with the names of M. Calmette, of the Pasteur Institute at Lille, and M. Phisalix, of Paris.

Dr. F. C. Purcell exhibited some reputed venomous spiders and scorpions, and made some remarks thereon.

Ordinary Monthly Meeting.

January 27, 1904.

Dr. J. D. F. Gilchrist, President, in the Chair.

Professor Payne was elected ordinary member.

Dr. Sinclair Stevenson was nominated as ordinary member by Dr. J. D. F. Gilchrist and L. Péringuey.

A paper on the High-Level Gravels of the Cape Colony and the "Problem of the Karroo Gold" was read by Mr. E. H. L. Schwarz.

Mr. Schwarz pointed out that the high-level gravels of the Cape Colony are a series of river deposits that are now found perched high up on the tops of hills. When any large tract of country where these occur is looked at from a distance the gravels are seen to rest on a plateau or plain of erosion; that is to say, the rivers at one time had reached their base-level, and instead of cutting downwards were forced to meander backwards and forwards, reducing all irregularities of the surface to a more or less dead level. On the coast, this was undoubtedly caused by the ground in these remote times having been very much lower, so that the rivers entered the sea on nearly the same level as the high-level flats themselves. Behind the coastal ranges, however, it was probably the bars in the rivers that caused the base-levelling; most of the great rivers in the western part of the Colony come through poorts in the

mountains, and the time consumed in reducing the level of these poorts was sufficient to allow the rivers to cut extensive plains behind them. The plains may be divided into four sets: No. 1, the Agulhas Plain, whose edge is known as the Agulhas Bank, was almost certainly dry land at one time, but it is now covered with 40 fathoms of water. No. 2, the Ruggens and flat-topped hills and coastal plains all along from Cape Point to the Natal border. This is often divided into several stages, each forming a vast step. After the initial rise, the rivers once more cut vigorously downwards, and have cut deep gorges, 500 to 800 feet deep, in this old land surface. No. 3, a series of plains in between the parallel coastal ranges. Owing to the narrowness of the space these are seldom true, level plains, but can be better described as bevels or inclined plains. No. 4, a plateau of about 3,500 feet above the sea-level, of which only a few remnants can be seen here and there. Nos. 3 and 4 are probably in places confluent, and possibly also formed in remote times one vast shelving tract of open plain from the Nieuweveld and Camdeboo Mountains to the sea by Port Elizabeth. Near the mountains these old land surfaces are covered with gravel, but further away there is more sand, yet all varieties of river-borne material occur. The sand when exposed on the hill-tops has been mistaken, from its peculiar position and appearance, for lava flows, diamond breccia, and gold quartz; the sand, cemented either by infiltration of iron or of silica, becomes either an ironstone or a quartzite. Excellent building stones occur among these deposits. The Prince Albert Gold Fields were opened in 1891, amid great excitement, 1,042 claims being registered in the first four months and 504 ounces of alluvial gold found. The fields attracted a great deal of attention, and a large amount of prospecting was carried on in the neighbourhood, but no reefs have up to the present been discovered. In the Zwartebergen, however, there is always a little gold to be found in the sandstone, especially in the neighbourhood of gravel or banket reefs, as in the Millwood gold area in Knysna. Such banket reefs, of which photographs and specimens were exhibited, occur in the Zwartebergen. It is now certain that the hills at the Prince Albert Gold Fields once formed part of the great plateau of which traces can be found on the sides of the Zwartebergen and on the outer range of hills made of Witteberg beds, and as this was formed by the cutting of rivers flowing northwards from the mountains, it is highly probable that the Prince Albert gold came from the Zwartebergen, and not from its disintegration of reefs in the neighbourhood, the latter being in rocks of comparatively recent age, and, therefore, hardly to be expected to be metalliferous.

Ordinary Monthly Meeting.

March 2, 1904.

Dr. J. D. F. Gilchrist, President, in the Chair.

Dr. E. Sinclair Stevenson was elected ordinary member.

Messrs. H. B. Brown and D. J. Haarhoff were nominated as ordinary members by J. R. Sutton and L. Péringuey.

Dr. Gilchrist exhibited a cluster of fish eggs attached to a piece of "red bait" (a large ascidian) from False Bay. They were small beings, a little less than 1 millimeter in diameter. A few oil globules occurred in the yolk mass which were of a dull yellowish colour. The embryos were fairly well advanced when procured, and some of them had hatched out. They were thought to belong in all probability to a species of blenny, probably *Blennius cornutus*, which occurs in False Bay. This is the third kind of demersal fish egg found in Cape waters, one of the other two has now been found to be that of a species of *Lepidogaster*, hitherto unrecorded.

Mr. A. W. Rogers read a paper written in collaboration with Mr. A. L. du Toit on "The Sutherland Volcanic Pipes and their relation to other vents in South Africa."

In the Sutherland Division there are 30 volcanic pipes filled with materials of various kinds. They occur on the Commonage west of the village, at Matjesfontein, Silver Dam, Saltpetre Kop, Blaauw Blommetjes Keep, De Vrede, and Portugal's River. They can be divided into three classes:—

1. Those filled by melilite-basalt or glassy lava. (Commonage.)
2. Those filled partly by melilite-basalt or glassy lava and partly by tuff. (Commonage and Matjesfontein.)
3. Those filled with breccias. (Silver Dam, Saltpetre Kop, Blaauw Blommetjes Keep, De Vrede, and Portugal's River.)

All these pipes pierce the Beaufort beds which are slightly upturned at the contact with the pipes. In the case of the large vent of the Saltpetre Kop group the strata dip away from it on all sides, at first steeply (50°–90°), but they become horizontal at a distance of rather over a mile. The melilite-basalts are composed of olivine, melilite, biotite, augite, perofskite, ilmenite, and a devitrified base containing serpentine and calcite. Some outcrops are much altered, but at more than one the component minerals are remarkably fresh. They show a general resemblance to the melilite-basalt of Spiegel River, which is also described in the paper, and of which a complete chemical analysis by Mr. J. Lewis of the Government Laboratory is

given. On account of the freshness of this rock this analysis is an important addition to the few hitherto made of melilite-basalts. The Spiegel River rock penetrates the Uitenhage beds, and if, as the authors suggest, the community of character is evidence of contemporaneity, the presence of melilite-basalt in the Sutherland pipes affords a clue to their age and to that of the related volcanoes. The breccias consist of a serpentinous, calcareous, or silicious groundmass containing many varieties of sedimentary rocks derived from the Karroo formation, and deep-seated igneous rocks, such as gneiss, granite, granulite, eclogite. The two latter are very basic and consist chiefly of pyroxenes (monoclinic), brown hornblende, garnet, biotite, and ilmenite. From these rocks were derived the numerous pieces of pyroxene, hornblende, ilmenite, and biotite that occur in the breccias. The resemblance of these breccias to the contents of the pipes at Balmoral, Kimberley, Jagersfontein, the Monastery mine, and the Newlands mine are pointed out, and some notes on the nature of some of the Kimberley rocks bearing upon the question of the original character of the magma from which the blue-ground was derived are given.

Ordinary Monthly Meeting.

March 30, 1904.

Dr. J. D. F. Gilchrist, President, in the Chair.

Messrs. H. B. Brown and D. J. Haarhoff were elected ordinary members.

Dr. Eric France, Dr. Warren, and Professor A. Brown were nominated by Messrs. W. L. Sclater and L. Péringuey, and Dr. J. A. Beattie and the President.

Two papers were read:—"On Two New Therocephalian Reptiles (*Glanosuchus macrops* and *Pristerognathus baini*)," by R. Broom, M.D.

"Note on the valuation by successive approximation of the series for sin θ and cos θ in ascending powers of θ," by Professor Laurence Crawford.

Dr. R. Marloth read the following Notes:—

1. When he visited the Matopo hills in November of last year, he noticed a shrub a couple of feet high which looked quite withered. It was common everywhere in the fissures or depressions of the granite, but although he kept a good look-out he was unable to find any fresh specimen. This was strange, for unless a special epidemic

had killed them all, he was unable to understand this general occurrence of apparently shrivelled shrubs without a single living one. He took a piece with him and on examining it microscopically about a month afterwards he noticed some green living tissue in the leaves. He immersed the twig in water, whereupon it gradually unfolded its leaves, exposing their bright green upper surface. He had evidently found a kind of resurrection plant, which retains its leaves during the dry season instead of dropping them like so many other tropical and sub-tropical shrubs and trees. The leaves simply rolled themselves up and become appressed against the branches, looking brownish-grey like the bark of the twigs. In that state they remain during winter and spring until the rain rouses them from their winter sleep.

As might have been expected under the circumstances, one finds no stomata on the lower side of the leaves but only on the upper side. Thus, in the shrivelled state of the leaf its stomata are specially protected against communication with the outer air and transpiration is consequently greatly impeded.

As the plants had neither flowers nor fruits on them when gathered, he could only surmise from the general appearance of the leaves that it may be a species of Cliffortia or of some allied genus of the order Rosaceæ.

The living plant exhibited there that night he obtained through the kindness of Mr. Dowsett, the superintendent of the Rhodes-Matopo park.

2. The wild rye (*Secale africanum* Stapf) was recorded for the first time by Thunberg, when he passed through the Roggeveld in 1774. He took it to be a wild form of the common cultivated rye, which fact shows that it resembles it very much indeed, and he mentions that the district had been named after this grass. Since that time no specimens of the plant had ever been gathered, and it was not represented in any herbarium in South Africa until these specimens were found a few weeks ago. For several years Dr. Marloth endeavoured to procure some through the kindness of friends travelling in that district, but it is only now that Mr. Izaac Meiring succeeded in obtaining it for him in the Sutherland district. All his inquiries among the farmers there had shown that this grass is rare, and that the idea that it yielded any grain for the use of the farmers, or even any pasture for the stock was erroneous.

It is of considerable interest not only because it has given its name to a large district of the country, but also on account of the distribution of the few species of the genus *Secale*. There are only four species of this genus known, two of them being so nearly allied

to each other that they are mostly considered to be mere varieties.

Most botanists look upon *S. cereale* as a descendant of *S. montanum* modified by cultivation, for the former is not known to grow wild anywhere. As long as the wild rye of the Roggeveld was thought to be merely a form of the cultivated species, it was possible to presume that it had been introduced and escaped from cultivation. Since Stapf, however, has shown that it differs considerably from the cultivated rye and that it must be considered to be a distinct species, another puzzle has been added to the many already in existence for the student of the distribution and the origin of the plants of South Africa.

Mr. Lounsbury exhibited specimens of *Rhipicephalus appendiculatus*—a species of tick which has been found to transmit African Coast fever and which may be the only species concerned. The tick occurs in the coastal districts of the Colony from Cape Town eastward as well as in Rhodesia, Transvaal, Natal, and along the east coast in German and Portuguese territory. The disease has spread down the east coast and inland into Rhodesia, Transvaal, and Zululand, and since the tick is here to transmit it, there is danger of its ultimately extending over the coast districts of the Colony. The demonstration that the particular tick was the means for spreading the disease was made by the Agricultural Department at the Animal Diseases Experimental Station, Rosebank, near Cape Town. The ticks used were the progeny of specimens collected in the Colony and were all fed once, that is as larvæ, on cattle in Cape Town to make certain that they were innocuous at the start. Then as nymphs they were taken to Bulawayo and there fed on an animal dying with the disease; afterwards they were returned to the Cape, and since they have transformed to the adult stage some have been used to infect six cattle. All the animals have become infected with the disease and five have died with it. One of the cases followed the attack of a single tick and another the attack of two ticks. The incubation period, that is the time from the application of the ticks to the appearance of the fever, was about fifteen days in all. Similar tests in which other species of ticks were used have given negative results.

Mr. L. Péringuey exhibited a lion skull said to have been discovered in a bushman's cave near Van der Byl's kraal in the Prince Albert division. On examination it is seen that the triangular iron tip of a long bushman's arrow is so deeply imbedded in the premaxillary bone as to have actually split the large canine at the base of the socket. The shot was delivered most probably at close

quarters through the anterior narial aperture. He exhibited also, in connection with the skull, types of different bows and arrows formerly used by bushmen.

Ordinary Monthly Meeting.

May 25, 1904.

Dr. J. D. F. Gilchrist, President, in the Chair.

Dr. Eric France, Dr. E. Warren, and Professor Brown were elected ordinary members.

Mr. H. R. Arderne was nominated by Messrs. W. G. Fairbridge and L. Péringuey; Dr. W. Besté, by Messrs. C. Stewart and L. Péringuey; Mr. W. B. Gordon, by Dr. Gilchrist and L. Péringuey; and Mr. O. T. Hennessy, by Messrs. W. L. Sclater and L. Péringuey.

A letter was read from the Royal Asiatic Society, Bombay, inviting the Society to send delegates to celebrate the Centenary of the Bombay Literary Society, now affiliated to the Royal Asiatic Society, to commence in January, 1905.

Dr. R. Broom's paper, "The Origin of Mammalian Carpus and Tarsus," was read.

Dr. R. Marloth spoke on "Mimicry among Plants."

Mimicry among animals was of general occurrence, and South Africa possessed remarkable forms of this kind. He instanced some of these, and said that one could not but admire the perfect similarity of these insects with the plants among which they lived. There was a great difference with regard to mimicry among plants. Many of these described as mimicries among plants appeared to him to be due to teleological speculation and the imagination of the writers. One of the commonest was known as the white dead nettle, which was supposed to mimic in its foliage the stinging nettle. In all probability the popular names of the two plants had something to do with the view that the dead nettle should find some protection in this similarity of foliage. He thought the similarity was a mere coincidence. There was, on the other hand, a number of instances in which the similarity of parts of plants to others was so striking that one could hardly doubt that they had been acquired by natural selection. An example of this kind was afforded by some *Stapelias*, a group of succulent plants which had its headquarters in South Africa.

He gave evidence of facts in this regard met with in South Africa. In concluding, he would like to sum up his views on this question as far as South African plants were concerned. Some of these seemed to occur only on fields of white quartz, where they were not easily distinguished, particularly at night-time, owing to their own white colour. It was probable that the limited occurrence in these districts was due to the destruction of individuals which sprung up in other localities, where their whiteness easily betrayed them to the night-feeding animals. Examples were the *Anacampseros papyracea* and a species of *Mesembrianthemum*. There were some species of *Mesembrianthemum* which were so well hidden among the fragments of yellow and brown shale that they were most difficult to detect. Yet this was not true mimicry, for after these plants were cultivated in a moister climate, *e.g.*, at Cape Town, they produced green leaves. This showed that the yellow and brown colouring were the effect of the Karroo climate, and not protective adaptation, although the plants had obtained efficient protection from them in their natural surroundings. There were, however, some species of *Mesembrianthemum*, viz., *M. Bolusi* and *M. nobile*, which retained their remarkable structure even under cultivation, although the leaves were somewhat less dull under these modified conditions, and lost consequently some of their desert character. This, he thought, was Mimicry, or, if one preferred the word, "Homoplasy." It was possible that *Mesembrianthemum truncatum*, Th., and *M. truncatellum*, Haw., were also some examples of this group.

Ordinary Monthly Meeting.

June 29, 1904.

Dr. J. D. F. Gilchrist, President, in the Chair.

Messrs. H. R. Arderne, Dr. W. Besté, W. B. Gordon, and O. T. Hennesey were elected ordinary members.

Dr. R. Broom's paper on "The Structure of *Mesosaurus*" and Dr. W. F. Purcell's "Descriptions of New Genera and Species of South African Spiders" were read.

Dr. J. D. F. Gilchrist exhibited a deep-sea fish (*Catætyx messieri*), along with some of its eggs and several embryos. These embryos had been found among the eggs, thus proving that the fish is vipiparous. Evidence was adduced to show that it is probable

that the embryos, after hatching, live for a time on the eggs which are not so far advanced, one case being found which seemed to indicate that the advanced embryos devour those less advanced. A male fish of about the same size (2 feet) has also been found, and showed a peculiar copulatory organ in accordance with the fact that the female is viviparous.

Both fish were found in the deeper waters near the Agulhas Bank during the investigations of the Government trawler *Pieter Faure*. The only other specimen of this fish that has yet been found was the type specimen procured by the *Challenger* in the Messier Straits, and this was evidently immature, being only 7 inches in length.

Mr. J. Stuart Thomson, F.L.S., exhibited specimens of *Cephalodiscus*, a possible primitive vertebrate, procured for the first time in South African waters by the Government trawler *Pieter Faure*. Colonies of this remarkable genus were obtained from three different localities, namely, off Cape St. Blaize, off Cape St. Francis, and off Cove Rock, East London. *Cephalodiscus* was discovered during the voyage of the *Challenger* in the Strait of Magellan, and was firstly supposed to be a compound *Ascidian*. When it was found not to belong to this class, and after having been examined by various authorities, it was sent to Professor McIntosh, F.R.S., in the hope that it might be found to possess affinities with *Annelids*. In his *Challenger* Report, McIntosh places *Cephalodiscus* with the *Polyzoa*, but at the same time notes its possession of certain characters common to *Balanoglossus*. In an appendix to this report, Harmes drew emphatic attention to more important affinities between *Cephalodiscus* and *Balanoglossus*, and proposed that the former should be entirely removed from the Polyzoa, and be placed with *Balanoglossus* at the base of the *Phylum Vertebrata*. Later, Masterman held that *Cephalodiscus*, *Phoronis*, and *Rhabdopleura* should be included in a specially constituted class, the *Diplochordata*, as distinguished from the *Hemichordata*, including *Balanoglossus*. He founded this classification mainly on the supposed occurrence of a double notochord in these three genera. The re-discovery of *Cephalodiscus* is of interest in two connections, firstly that it may be possible to trace out the development, which it has not been possible hitherto to investigate, and thus light would be thrown on its true affinities; and, secondly, one of the specimens dredged by the *Pieter Faure* is apparently a different species from that discovered by the *Challenger*.

Annual General Meeting.

August 17, 1904.

The President, Dr. J. D. F. Gilchrist, in the Chair.

The Secretary, the Treasurer, and the Librarian read their Reports for the year ended June 30, 1904.

Dr. J. D. F. Gilchrist was re-elected President for the year 1904–1905.

Messrs. L. Crawford, Wm. Flint, R. Marloth, J. T. Morrison, and Sir David Gill were elected members of the Council for two years, and Mr. H. W. W. Pearson for one year.

The President delivered the Annual Address, taking for his subject "Some Features of the Marine Fauna of South Africa."

General Report and Statements for the Year ended June 30, 1904.

COUNCIL.

J. D. F. Gilchrist, M.A., Ph.D., *President.*
Sir David Gill, K.C.B., F.R.S., *Vice-President.*
J. C. Beattie, D.Sc., F.R.E.S.
L. Crawford, M.A., D.Sc.
R. Marloth, M.A., Ph.D.
W. F. Purcell, M.A., Ph.D., *Hon. Treasurer.*
L. Péringuey, F.Z.S., *Hon. Secretary.*
T. Muir, C.M.G., F.R.S., LL.D.
W. L. Sclater, M.A., F.Z.S.

Ten ordinary meetings and one general meeting were held during the year. Twelve original papers were read or taken as read, and three addresses given by Messrs. Thomson, Sclater, and Dr. Broom respectively. The original papers are :—

"Descriptive Catalogue of the South African Coleoptera" (continued), by L. Péringuey.

"A Note on the quantities given in Dr. Marloth's paper on the moisture deposited from the South-East Clouds," by C. M. Stewart.

"An Introduction to the Study of South African Rainfall," by J. R. Sutton.

"Factorizable Continuants," by T. Muir.

"Developments of a Pfaffian," by T. Muir.

"The High-Level Gravels of the Cape Colony," and the "Problem of the Karroo Gold," by E. H. L. Schwarz.

"The Sutherland Volcanic Pipes and their relation to other vents in South Africa," by A. W. Rogers and A. L. du Toit.

"On two new Therocephalian Reptiles (*Glanosuchus macrops* and *Pristerognathus Bainii*)," by R. Broom.

"The Origin of the Mammalian Carpus and Tarsus," by R. Broom.

"Mimicry among Plants," by R. Marloth.

"The Structure of Mesosaurus," by R. Broom.

"New Genera and Species of South African Spiders," by W. F. Purcell.

In addition to the papers read at the ordinary meetings, there were important exhibitions that led to interesting discussions.

Parts 3, 4, 5 of Vol. XIV. and Part 1 of Vol. XV. of the *Transactions* have been issued during the year, and the other papers are in the hands of the printer. Two other parts are expected here within one month or six weeks, and the balance will certainly be issued before the end of the present year.

Two receptions have been held—one in connection with the meeting of the Medical Congress in Cape Town, the other to enable members of the Society and their friends to meet and welcome the leader and scientific staff of the Scottish Antarctic Expedition on board the *Scotia*. Mr. Bruce, the leader, gave an account of the work of the expedition.

Three members have resigned; one died; four have been removed for long arrears of subscription. Our number is, however, increasing. Our roll shows a membership of 218 ordinary and of 4 honorary members, divided as follows: Cape Colony, 173; Transvaal, 20; Natal, 14; Rhodesia, 8; and Orange River Colony, 2.

The Cape Government has not granted this year that subsidy of £100 which went far to cover part of our printing expenses. A gratifying feature, however, of the Treasurer's statement is the sale of publications, which amounted to £67 14s. 3d. during the year.

The Treasurer's Report shows a credit balance to the 30th of June of £312 18s. 0½d.

The Hon. Treasurer in Account with the South African Philosophical Society, July 1, 1903, to June 30, 1904.

Receipts.

	£ s. d.	£ s. d.
To Balance in Bank on fixed deposit at 3½ per cent. ..	300 0 0	
,, Floating Balance in Bank, as per Bank book	27 3 3	
,, Petty Cash Balance	3 13 11	
		330 17 2
,, Subscriptions—		
1 Full Subscription, Country, 1901	1 0 0	
1 ,, ,, Town, 1902	2 0 0	
6 ,, Subscriptions, Country, 1902..	6 0 0	
13 ,, ,, Town, 1903	26 0 0	
17 ,, ,, Country, 1903..	17 0 0	
74 ,, ,, Town, 1904	148 0 0	
51 ,, ,, Country, 1904..	51 0 0	
1 ,, Subscription, Country, 1904..	1 0 0	
1 ,, ,, Country, 1906..	1 0 0	
1 Country Life-Member's Subscription..	12 0 0	
Fractional Subscriptions of new members and odd shillings sent to cover exchange, &c. ..	8 6 6	
8 Entrance Fees	8 0 0	
		281 6 6
,, Interest on money at fixed deposit		10 10 0
,, 42 Subscriptions * to Refreshment Fund for Special Meeting and Reception to Medical Congress on December 29, 1903		14 3 6
,, Sale of Society's Publications		67 14 3
,, Refund to Society for extra author's copies		6 19 2
[* 9 Subscriptions are still outstanding.]		£711 10 7

Expenditure.

	£ s. d.	£ s. d.
By Publications—		
Messrs. West, Newman & Co., for printing—		
Vol. XI., title..	1 10 0	
Vol. XIV., pts. 1 and 2, balance	46 2 6	
,, pts. 3 and 4	101 18 6	
,, pt. 5	20 19 0	
M. Dujardin for 3 plates for Vol. XIII.	19 18 0	
H. Knight for drawing—		
Plate 43 of Vol. XIII...	4 4 0	
Plate 8 of Vol. XIV.	4 4 0	
		198 16 0
,, Local printing or typewriting of—		
Notices of meetings	6 10 6	
Minutes of meetings	6 10 6	
Circulars, rules, &c.	22 13 6	
		35 14 6
,, Freight on publications..		15 2 8
,, Stationery		5 10 0
,, Rent for Library, July, 1903, to June, 1904		36 0 0
,, Attendant and caretaker for library and meeting rooms, January, 1903, to December, 1903		5 0 0
,, T. D. Butler for clerical assistance, April, 1903, to March, 1904 ..		4 15 0
,, Special Meeting and Reception to Medical Congress on December 29, 1903—		
Hire of hall, limelight, &c.	5 7 6	
Catering	17 3 0	
		22 10 6
,, Special Meeting and Reception to *Scotia* Antarctic Expedition in Y.M.C.A. Hall on May 10, 1904		27 13 3
,, Compilation of International Catalogue of Scientific Literature	10 0 0	
,, Cardslips for same	0 4 0	
		10 4 0
,, Postage stamps		29 0 0½
,, Binding of books		2 12 6
,, Petty expenses and Bank charges		5 14 1
		398 12 6½
,, Balance in Bank on fixed deposit at 3½ per cent. ..	250 0 0	
,, Cash in hand not paid into Bank by June 30, 1904 ..	20 6 9	
,, Floating Balance in Bank	35 14 8	
,, Petty Cash Balance	6 16 7½	
		312 18 0½
		£711 10 7

We, the undersigned members of the South African Philosophical Society, hereby declare that we have examined the above account, compared the receipts with the counterfoils of the Receipt Book, the cash payments with the Vouchers, and the balance with the Bank Pass Book, and have found the same correct.

(Signed) E. H. L. Schwarz, A. L. du Toit } *Auditors.*

REPORT OF THE LIBRARIAN.

The Librarian has pleasure in reporting many valuable accessions and additional exchanges during the year 1903–4.

Towards the end of 1902 a circular letter was sent to a number of well-known societies whose publications were not received by this Society nor by any other institution in Cape Town. It was sympathetically answered in all cases in which an answer was received. The Göttingen, the Leipzig, and the Vienna Academies of Science have agreed to send from the present time the scientific sections of their publications in exchange for our *Transactions*. The societies of Rome, of Naples, and of Turin have agreed to do the same. In addition, these societies have agreed to let this Society have their publications in exchange for ours for all years for which our Society has publications of its own to offer in return. It has also been arranged to have exchanges with the American Association for the Advancement of Science, and with the Gesellschaft Deutscher Naturforscher und Aerzte.

The Institution of Civil Engineers has supplied copies of its Minutes and Proceedings, completing as far as it was able the set of its publications in the possession of this Society.

The Royal Colonial Institute has presented a set of its publications. Volumes, or parts of volumes, missing, have been received from the Société des Sciences Naturelles de l'ouest de la France; from Mr. H. C. Russell, in connection with the Meteorology and Rainfall publications of New South Wales; from the Institut Colonial de Marseilles; and from the Faculté des Sciences de Marseilles; the Geographical Journal; Scottish Geographical Magazine; the Secretary of the Meteorological Commission, Cape Town; the Government Entomologist, Cape Town; and the Director of the Geological Survey, Cape Town

The Entomological Society of Holland has presented the Society with a complete set of its publications.

The Society owes thanks to these and to other societies for the ordinary exchanges of the year. The Society has also to acknowledge with thanks the receipt of copies of author's reprints received from Messrs. H. C. Russell, E. Cohen, Charles Janet, S. S. Hough, L. Crawford, J. C. Beattie, F. P. Mennell.

The Cape Government has generously donated a set of the parts of the International Catalogue of Scientific Literature which have

appeared up to date, and the Society is to receive henceforth a copy of this invaluable publication.

The Librarian has to report with regret that he has not been able to prepare a catalogue of the library; that the present accommodation is insufficient and in some ways unsuitable; that he has not been able to spend the whole of the grant voted by the Council for the library.

ADDITIONS TO THE LIBRARY.

ADELAIDE.

Transactions of the Royal Society of South Australia, vol. xxii., pt. 2.

Proceedings of the Royal Geographical Society of Australia, South Australian Branch, vols. v., vi.

AGRAM.

Jahrbuch des Meteorologischen Obs. in Agram für 1901. Jahrgang I.

AMSTERDAM.

Proceedings of the Section of Sciences, Royal Academy of Sciences, vols. iv., v.

AUSTIN.

Transactions of the Texas Academy of Science, vol. v.

BALTIMORE.

Bulletin of the Johns Hopkins Hospital, Nos. 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 149, 150, 151, 152, 153.

Johns Hopkins University Studies in Historical and Political Science, series xix., Nos. 10, 11, 12; series xx., No. 1.

Johns Hopkins University Circulars, vol. xxi., Nos. 159, 160.

BASEL.

Verhandlungen der Naturforschenden Gesellschaft, Band xiii., Heft 1, 3, mit Anhang; Band xiv.; Band xv., Heft 1; Band xvi.

BATAVIA.

Medeelingen det 's lands plantentium, vol. lxvi.

Bulletin de l'Institut Botanique de Buitenzorg, No. xviii.

BERKELEY.

University of California Publications.

Zoology, vol. i., Nos. 1, 2.

Physiology, vol. i., Nos. 1, 2.

Univ. Bulletin, vol. iv., No. 2; vol. v., No. 1.

Berkeley (*continued*)—

Agricultural Experimental Station Bull., No. 147.
Lick Obs. Bull, No. 35.

Berlin.

Sitzungsberichte der Kön. Preuss. Akademie der Wissenschaften, 1902, 1903.
Veröffent. des Instituts für Meereskunde und des Geographischen Instituts an der Universität Berlin, Heft 1, 2.

Boulder, Colorado.

The University of Colorado, Studies, vol. i., Nos. 1, 2, 4.

Brooklyn, New York.

Cold Spring Harbour Monographs, Nos. i., ii.

Brussels.

Académie Royale de Belgique.
Bulletin de la Classe des Sciences, 1902, Nos. 4–12; 1903, Nos. 8–10; 1904, Nos. 1–2.
Annuaire de l'Académie Royale des Sciences et des Beaux-Artes de Belgique, 1903.

Buenos Ayres.

Anales del Museo Nacional, tom. vii., viii.

Bulawayo.

Proceedings of the Rhodesia Scientific Association, vol. iii., pt. 3.
Rhodesia Museum, Special Report.
,, ,, First Annual Report.

Calcutta.

Proceedings of the Asiatic Society of Bengal, 1901, Nos. 9–11; 1902, Nos. 1–11; 1903, Nos. 1–5.
Journal of the Asiatic Society of Bengal, vol. lxx., pt. 1, Nos. 1, 1*e*, 2, 2*e*; pt. 2, Nos. 1, 2; pt. 3, Nos. 1, 2; lxxii., pts. 1, 2, 2*e*; pt. 2, Nos. 1, 2; pt. 3, No. 1.

Cambridge, England.

Proceedings of the Cambridge Philosophical Society, vol. i., pts. 6, 7; vol. xii., pts. 1, 2, 3, 4, 5.
University Library. Report of the Library Synod for the year ending December, 1901.

Cape Town.

Annual Reports of the Geological Commission, 1900, 1901, 1902,
Reports of the Government Entomologist for the years 1895. 1896, 1897, 1898, 1899, 1900, 1901.

CAPE TOWN (*continued*)—

Annals of the South African Museum, vol. ii., pt. 9 ; iii., pt. 4 ; iv., pts. 1, 2.

Report of His Majesty's Astronomer at the Cape of Good Hope for the year 1901.

Report of the Colonial Veterinary Surgeon, 1902.

Report of the Senior Analyst, 1902.

Report of the Government Botanist, 1902.

Report of the Government Biologist, 1901.

Reports of the Meteorological Commission, 1877–1902.

CHICAGO.

Field Columbian Museum.

Report Series, vol ii., No. 1.

Geological Series, vol. i., Nos. 9, 10, 11 ; vol. ii., Nos. 1, 2, 3, 4.

Botanical Series, vol. i., No. 7, Title-page and Index to vol. i.

Zoological Series, vol. iii., Nos. 10, 11, 12, 13, 14.

CINCINNATI.

The Journal of the Cincinnati Society of Natural History, vol. xx., No. 2.

Bulletin of the Lloyd Library, No. 6. Mycological Series, Nos. 1, 2. Pharmacy Series, No. 1. Reproduction Series, Nos. 1, 2.

COLUMBUS.

Thirty-first Annual Report of the Board of Trustees of the Ohio State University, pts. 1, 2.

CORDOBA.

Bol. Acad. Nac. Ciencias en Cordoba, xvii., pts. 1, 2, 3.

DAVENPORT.

Proceedings of the Davenport Academy of Sciences, vol. viii.

DRESDEN.

Litteratur des Landes u. Volkskunde des Kön. Sachsens. Nachtrag. 4.

Verein für Erdkunde, Mitglieder Verzeichniss.

EDINBURGH.

The Scottish Geographical Magazine, vol. xvi., No. 10; vol. xviii., Nos. 1, 6–12, vols. xix., xx., Nos. 1, 2, 3, 4.

Proceedings of the Scottish Microscopical Society, vol. iii., No. 3.

GLASGOW.

Proceedings of the Royal Philosophical Society, vols. xxxiii., xxxiv.

GÖTTINGER.

Nachrichten von der König Gesellschaft der Wissenschaften, Math.-Phys. Class, 1894–1903.

Geschäftliche Mittheilungen, 1894–1903.

GREIFSWALD.

Das Meteoreisen von N' Goureyma, von E. Cohen.

,, ,, ,, Rafruti, von E. Cohen.

HALIFAX, N.S.

Proceedings and Transactions of the Nova Scotian Institute of Science, vol. x., pt. 3.

HALLE A. SAALE.

Leopoldina, Heft 34–37.

Nova-Acta, Band 69, Heft 1; Band 70, Heft 3.

HAMBURG.

Jahresbericht Hamb. Wissen. Anstalt, Band xix., Beiheft 1, 2, 3, 4; Band xx., Beiheft 1.

HAMILTON.

Journal and Proceedings of the Hamilton Scientific Association, vol. xviii., xix.

HEIDELBERG.

Berichte über Land und Forstwirthschaft in Deutsch Ost-afrika, Bd. i., Heft 3, 4, 5.

HERTFORD.

Contributions to South African Petrography, by F. P. Mennell, F.G.S.

HOBART.

Report of the Australian Association for the Advancement of Science, 1902.

INDIANAPOLIS.

Proceedings of the Indiana Academy of Science, 1901, 1902.

Twenty-sixth Annual Report of the Indiana Department of Geology and Natural Resources.

KASSEL.

Abhandlungen u. Bericht. des Vereins für Naturkunde, vol. xlviii.

La Plata.

Revista del Museo de la Plata, tomo x.

Lausanne.

Bulletin de la Société Vaudoise des Sciences Naturelles, Nos. 143, 144, 145, 147, 148.

Lawrence.

Bulletin of the University of Kansas, vol. ii., Nos. 7, 8; vol. iv., Nos. 6, 8.

Leipzig.

Verhandlungen der Gesellschaft Deutscher Naturforscher u. Aerzte. 71 Versammlungen, Munchen, 1899. 73 Versammlungen, Hamburg, 1901.

Lima.

Boletin del Cuerpo de Ingenieurs de Minas del Peru, Nos. 1, 3.

London.

The Geographical Journal, vol. xiv., No. 5; vol. xvi., No. 6; vol. xix., No. 6; vols. xx., xxi., xxii., xxiii., Nos. 1, 2.

Quarterly Journal of the Geological Society, Nos. 230–233, 236, 237.

Geological Literature added to the Geological Society's Library for the year ended December, 1901.

List of Fellows of the Geological Society.

Journal of the Anthropological Institute of Great Britain and Ireland, vol. xxxii.

Minutes and Proceedings of the Institution of Civil Engineers, vols. xxx.–cliv.

Brief Index to Subject Matter of Minutes C.E.

Subject Index of vol. 59–118 (M.C.E.).

Charter and List of Members of Institution of C.E., 1891, 1893, 1895, 1896, 1899, 1900.

Report of Council of Inst. of C.E., 1897.

Monthly Notices of the Royal Astronomical Society, vol. lxii., Nos. 6, 7, 8, 9; vol. lxiii., Nos. 1, 2, 3, 4, 9; vol. lxiv., Nos. 1, 2, 3, 4, 5.

Quarterly Journal of the Royal Meteorological Society, Nos. 123, 124, 125, 128, 129.

List of Fellows of the R.M.S., 1904.

Proceedings of the Royal Colonial Institute, vol. xxxiii.

Transactions of the Zoological Society of London, vol. xvi., pts. 4, 6, 7.

LONDON (*continued*)—

Proceedings of the Z.S., 1901, vol. ii., pt. 2; 1902, vol. i., pts. 1, 2; vol. ii., pt. 1; 1903, vol. ii., pt. 1.

List of the Fellows of the Z.S., London, 1891–1900, 1902.

International Catalogue of Scientific Literature, 1st series.

MADISON.

Transactions of the Wisconsin Academy, vol. xii., No. 1.

MANCHESTER.

Journal of the Manchester Geographical Society, vols. xvii., xviii., xix.

Memoirs and Proceedings of the Manchester Literary and Philosophical Society, vols. xlvi., xlvii., xlviii.

MARSEILLES.

Annales de l'Institut Colonial 4e année, 3e vol. (1896), 5e année, 4e vol. (1897).

Annales de l'Institut Botanico-Géologique, colonial de Marseilles, 1e Série, 1e année, 1er vol.

Annales de la Faculté des Sciences, tomes iii., iv., xii., xiii.

MELBOURNE.

Proceedings of the Royal Society of Victoria, vol. xv., Nos. 1, 2; vol. xvi. No. 1; xvii. No. 1.

MEXICO.

Memorias y Revista de la Sociedad Cientifica "Antonio Alzate," tome xvi., Nos. 2, 3, 4, 5, 6; xviii., Nos. 3, 4, 5; xix., Nos. 2, 3, 4.

Boletin Mensual del Obs. Met. Central, 1901, 1902.

Parergones del Instituto Geologico, tom. i., No. 1.

MISSOULA.

University Bulletin, Nos. 17, 18, 20.

Geolog. Series 1.

MONTE VIDEO.

Anales del Museo Nacional, tom. iv., No. 1.

MONTREAL.

Canadian Record of Science, vol. viii., No. 8; ix., No. 2.

NANTES.

Bulletin de la Société des Sciences Naturelles de l'Ouest de la France, tomes iv., vii., viii., ix. x.; 2me Ser., tomes i., ii., iii.

Table des matières, tomes i.–x.

NAPLES.

Rend. Acc. Sci. Fis. e Mat., vol. ix., Nos. 5, 7.

OBERLIN.

The Wilson Bulletin, Nos. 39, 40, 41, 42, 43, 44, 45.
Laboratory Bulletin, No. 12.

OTTAWA.

Transactions of the Ottawa Literary and Scientific Society, No. 3.
Geological Survey of Canada.
Catalogue of Canadian Plants.
Annual Report, New Series, vol. vi.
Geological Map of Dominion of Canada. Sheet 783.

PARIS.

La Feuille des Jeunes Naturalistes. Revue Mensuelle d'Histoire Naturelle, Nos. 379–384, 386–390, 396, 398, 400–402.

PERTH.

Annual Report of the Progress of the Geological Survey of West Australia for the year 1900.

PHILADELPHIA.

Proceedings of the American Philosophical Society, Nos. 167–174.
Proceedings of the Academy of Natural Sciences, vols. liii., liv., lv.

RIO DE JANEIRO.

Anal. Mus. Nac., vols. x., xi.

ROCK ISLAND.

Augustana Library Publications, No. 3.

ROME.

Atti R. Acc. dei Lincei, 1895–1903.

ST. PETERSBURG.

Mémo. Acad. Imp. Sci., vol. xi., pts. 1, 2, 5–8; vol. xii., pts. 1–4, 6–11; vol. xiii., pts. 1, 3–5, 7.
Bulletin, vol. xvi., pts. 4, 5; vol. xvii., pts. 1–4.

SAN FRANCISCO.

Proceedings of the Californian Academy of Sciences.
Math. Phys., vol. i., pt. 8.
Zoology, vol. ii., pts. 7–11; vol. iii., pts. 1–4, 5, 6.
Botany, vol. ii., pts. 3–9.

San Francisco (*continued*)—
Geology, vol. ii., pt. 1.
Occasional Papers, vol. viii.
Memoirs of the C.A. of Sciences, vol. iii.

Santiago.
Actes de la Société Scientifique du Chili, tom. xi., xii.

Stockholm.
Royal Swedish Academy of Sciences.
Bihang, vols. xxvii., xxviii.; Handlingar, vols. xxxv.–xxxvii.;
Ofversigt, vol. lviii., ars. 1903.
Antiq. Tidskrift för Sverige, vol. xvii., pts. 1, 2.
Konig. Vitterhets Hist. o. Antiq. Akad. Maradsblad, 1897.

Sydney.
Records of the Geological Survey of N.S.W., vol. vii., pts. 2, 3.
Handbook to the Mining and Geological Museum.
Memoirs Geol. Survey, N.S.W., Geology, No. 3.
Results of Rain, River, and Evaporation Obs. made in N.S.W. during 1895, 1896, 1899, 1900.
Meteorological Observations for 1876, 1885, 1891–1897, 1899.
Australian Museum.
Special Catalogue, No. 1.
Records, vol. iv., Nos. 6, 7, 8; vol. v., Nos. 2, 3.
Memoir, iv., Nos. 4, 5, 6, 7.
Scientific Results of the Trawling Exp.
Report of the Trustees, 1901, 1902.
Calendar of the University of Sydney, 1902.
Proceedings of the Linnean Society of New South Wales, vol. xxvii., pt. 4; vol. xxviii. pt. 3.
Journal and Proceedings of the R.S. of New South Wales, vols. xxxv., xxxvi.
Abstract of Proceedings, R.S., N.S.W.
Reprints of Papers, Science Laboratories, University, 1895–6, 1897–1903, two volumes.

Toronto.
Transactions of the Canadian Institute, No. 14.
Proceedings of the Canadian Institute, New Series, No. 11, vol. ii., pt. 5.

Turin.
Bolletino dei Musei de Zoologia ed Anatomia Comparata della R. Univers, Nos. 382–415, 416–432, 433–458.
Atti Acc. Sci., vols. 18–29.

UPSALA.

Bulletin of the Geological Institution of the University, vol. v., pt. 2.

URBANA.

Bulletin of the Illinois State Lab. of Natural History, vols. v., vi., pt. 2.

Biennial Report of the Director of the Illinois State Laboratory of Natural History, 1899–1900.

VIENNA.

Annalen des K. K. Naturhistorischen Hof Museum, vol. xv., pts. 3, 4; vol. xvi., pts. 1, 2, 3, 4; vol. xviii., pt. 1.

Jahrbuch der K. K. Central Institut für Meteorologie und Erdmagnetismus, vol. xxxix.

K. Akademie der Wissenschaften.

Denkschriften, Bänder 72, 73.

Sitz. ber. Math.-Natur. Wiss. Classe, band cx., heft v.–vii.; band cxi., heft 4–9.

Mittheilungen der Erd. Com., Nos. 1–8, 10–13.

WASHINGTON.

Smithsonian Institution.

Proceedings of the U.S. National Museum, vols. xxiii., xxiv.

Bulletin ,, ,, vols. l., li.

Annual Reports, 1901, 1902.

ZURICH.

Verteljahrsschrift der Naturforschenden Gesellschaft.

46 Jahrgang., heft 1, 3, 4.

47 ,, heft 1, 2.

Newjahrsblatt.

LIST OF MEMBERS

For year ending July 31, 1904.

HONORARY MEMBERS.

1897 Fisk, *Rev.* G. H. R., *C.M.Z.S.*, Church House, Cape Town.

1897 Trimen, R., *F.R.S.*, Entomological Society, London.

1900 Cohen, *Prof.* E., University, Greifswald.

1900 Seeley, *Prof.* H. G., *F.R.S.*, King's College, London.

ORDINARY MEMBERS.

1897 Alston, E. G., Cape Town.

1901 Alston, J. A., *M.R.C.S.*, Union Street, Cape Town.

1895 Alston, G., 1, Lilian Villas, Wandel Street, Cape Town.

1890 Amphlett, G. T., Standard Bank, Cape Town.

1901 Anderson, A. J., *M.A.*, *M.B.*, Medical Officer of Health, Cape Town.

1886 Anderson, T. J., *M.L.A.*

1900 Anderson, Wm., Geological Survey Office, Maritzburg, Natal.

1902 Andrew, D. C., Union Castle Co., Cape Town.

1877 Arderne, H. M., The Hill, Claremont, C. C.

1904 Arderne, H. R., Arderne's Buildings, Cape Town.

1895 Baker, H., Johannesburg.

1897 Barker, C. N., Rownham, Malvern, Natal.

1902 Barnard (Miss), L. M., Wynberg, C. C.

1901 Baxter, W., *M.A.*, South African College School, Cape Town.

1899 Beard, Herbert R., *B.A.*, Wynberg, C. C.

1897 Beattie, J. C., *D.Sc.*, *F.R.S.E.*, South African College, Cape Town.

1882 Beck, J. H. M., *M.D.*, Tulbagh.

1901 Benjamin, L. E., *B.A.*, *LL.B.*, Cape Town.

1899 Berry, *Hon. Sir* Wm. Bisset, *M.D.*, Houses of Parliament, Cape Town.

1894 Besté, *Rev.* W., Stutterheim, C. C.

1877 Bolus, H., *D.Sc.*, *F.L.S.*, Kenilworth, C. C.

1897 Brauns, H., *M.D.*, *Ph.D.*, Willowmore, C. C.

1903 Brink, A., Kimberley.

1903 Brooks, F., Bulawayo.

1900 Broom, R., *M.D.*, *B.Sc.*, Victoria College, Stellenbosch, C. C.

1904 Brown, W. H., P.O. Box 107, Kimberley.

1877 Buchanan, *Hon. Sir* John, Claremont, C. C.

1902 Campbell, L. G., *M.D.*, Durban, Natal.

1902 Casalis, G. A., *M.D.*, Claremont, C. C.

1898 Churchill, F. O. F., Wyebank, Natal.

1899 Clark, G. M., *M.A.*, *A.M.I.C.E.*, P.O. Box 1,113, Johannesburg.

1900 Clifton, G. H., *M.D.*, Green Point, C. C.

1901 Colson, R., Lydenburg, Transvaal.

1901 Cookson, B., *M.A.*

1896 Cooper, A. W., Richmond, Natal.

1895 Corstorphine, G. S., *B.Sc.*, *Ph.D.*, P.O. Box 1,167, Johannesburg.

1896 Cowper, Sydney, *C.M.G.*, C. C.

1901 Cox, *Dr.* J. H., Colonial Office, Cape Town.

1901 Craig, William, *A.M.I.C.E.*, Public Works Dept., Cape Town.

1899 Crawford, Lawrence, *M.A.*, *D.Sc.*, South African College, Cape Town.

1895 Cregoe, J. P., P.O. Box 1,420, Johannesburg.
1903 Dendy, A., *D.Sc.*, South African College, Cape Town.
1902 Dinter, Kurt, Windhoek, German S.W. Africa.
1890 Dodds, W. J., *M.D.*, Valkenberg, Mowbray, C. C.
1902 Dodt, J., Museum, Bloemfontein, O. R. C.
1899 Don, David, The Maze, Berea, Durban, Natal.
1898 Drege, J. L., Port Elizabeth, C. C.
1901 Dwyer, F. L., C.G.R., Cape Town.
1903 Dyer, B., Library, Kimberley, C. C.
1877 Ebden, *Hon.* A., Rondebosch, C. C.
1897 Edington, A., *M.B.*, Graham's Town, C. C.
1895 Evans, M. S., *F.Z.S.*, Durban, Natal.
1903 Eyles, F., Bulawayo, Rhodesia.
1890 Fairbridge, W. G., 133, Long-market Street, Cape Town.
1899 Feltham, H. L. L., P.O. Box 46, Johannesburg.
1900 Findlay, F. N. R., Rustenburg, Transvaal.
1902 Finnemore, *Hon.* Mr. Justice R. I., *F.R.S.A.*, Supreme Court, Maritzburg.
1902 Fismer, F., *M.D.*, Wandel Street, Cape Town.
1901 Fitt, J. E., *A.M.I.C.E.*, Public Works Dept., Cape Town.
1892 Fletcher, W., Ratel River, Caledon, C. C.
1901 Flint, *Rev.* Wm., *D.D.*, Rosebank, C. C.
1901 Fourcade, H. G., Forest Dept., Cape Town.
1903 France, *Dr.* E., South African Association Building, Cape Town.
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1899 Fuller, C., *F.E.S.*, Agricultural Dept., Maritzburg.
1895 Fuller, E. Barnard, *M.B.*, Cape Town.
1896 Gilchrist, J. D. F., *M.A.*, *B.Sc.*, *Ph.D.*, South African Museum, Cape Town.
1879 Gill, *Sir* David, *K.C.B.*, *LL.D.*, *F.R.S.*, Royal Observatory, Cape Town.
1904 Gordon, W. B., Public Works Dept., Cape Town.
1897 Graham, F. G. C., Graham's Town, C. C.
1901 Graham, *Hon.* T. L., Sonnenstrahl, Wynberg, C. C.
1901 Grant-Dalton, A., *M.I.C.E.*, Cape Govt. Railways, Cape Town.
1899 Gray, Charles J., Department of Mines, Maritzburg.
1903 Griffiths, W. L., *M.D.*, Mansion House Chambers, Cape Town.
1897 Gunning, J. W. B., *Ph.D.*, The Museum, Pretoria.
1901 Hallack, J. G., Mowbray, C. C.
1898 Hamilton, T. H., Engineer's Dept., C.G.R., Cape Town.
1891 Hammersley-Heenan, R. H., *M.I.C.E.*, Table Bay Harbour Board, Cape Town.
1902 Havers, P., Stellenbosch, C. C.
1902 Hayward, S. H., Hofmeyr Chambers, Cape Town.
1901 Hely-Hutchinson, *H.E.*, The *Hon. Sir* W. F., *G.C.M.G.*, Government House, Cape Town.
1904 Hennesy, O. T., Arderne's Buildings, Cape Town.
1902 Herbert, H. A., African Banking Corporation, Cape Town.
1901 Hewat, M. L., *M.D.*, Steyning, Mowbray, C. C.
1901 Hirst, W., Johannesburg, Transvaal.
1900 Honey, J. W., Customs House, Pretoria.
1902 Hoop, van der, A. C., Consul-General for the Netherlands, Cape Town.
1901 Horn, W. J., South African College, Cape Town.
1899 Hough, S. S., *M.A.*, *F.R.S.*, Royal Observatory, C. C.
1889 Howard, R. N., *M.R.C.S.*, O'okiep, C. C.
1897 Hugo, D. de Vos, *M.B.*, Worcester, C. C.
1896 Hugo, *Hon.* J. D., Worcester, C.C.
1891 Hutcheon, D., *M.R.C.V.S.*, Dept. Agriculture, Cape Town.
1897 Hutchins, D. E., *F.R.M.S.*, Kenilworth, C. C.

1903 Innis, R. T. A., Meteorological Dept., Johannesburg.
1883 Janisch, N., Colonial Office, Cape Town.
1903 Johnson, J. P., Cleveland, Johannesburg.
1898 Juritz, C. F., *M.A.*, Government Laboratory, Cape Town.
1902 Kilpin, E. F., *C.M.G.*, Houses of Parliament, Cape Town.
1902 Kipling, Rudyard, Rottingdean, Brighton, England.
1896 Kitching, C. McGowan, *M.D.*, Church Street, Cape Town.
1896 Kolbe, *Rev.* F. C., *B.A.*, *D.D.*, St. Mary's Presbytery, Cape Town.
1900 Krapohl, J. H. C., *B.A.*, Concordia, C. C.
1903 Ladds, J. G. McLear, Cape Govt. Railways, Cape Town.
1903 Landsberg, E., *M.B.*, Cape Town.
1900 Lawn, *Prof.* J. G., Johannesburg.
1901 Leslie, T. N., Vereeniging, Transvaal.
1902 Lewis, A. J., Government Laboratory, Cape Town.
1902 Lewis, C. E., *M.A.*, South African College, Cape Town.
1877 Lightfoot, The *Ven. Archdeacon*, Cape Town.
1888 Lindley, J. B., *C.M.G.*, *M.A.*, *LL.B.*, Claremont, C. C.
1892 Lithman, K. V., Dock Road, Cape Town.
1896 Littlewood, E. T., *M.A.*, *B.Sc.*, High School, Wynberg, C. C.
1901 Logeman, W. S., South African College, Cape Town.
1895 Lounsbury, C. P., *B.Sc.*, Department of Agriculture, Cape Town.
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1902 Maberly, *Dr.* J., Woodstock.
1899 McEwen, T. S., *A.M.I.C.E.*, General Manager Cape Govt. Railways, Cape Town.
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1900 Macmillan, B. R., Department of Agriculture, Cape Town.
1897 Macpherson, J. W. C., *M.B.*, Stellenbosch, C. C.
1902 Mallison, P. R., Hex River, C. C.
1900 Mally, C. W., *B.Sc.*, Department of Agriculture.
1894 Mally, L., 8, Shortmarket Street, Cape Town.
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1898 Mansergh, C. L. W., Public Works Department, Cape Town.
1885 Marloth, R., *Ph.D.*, *M.A.*, Church Street, Cape Town.
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1900 Masey, F. E., Rhodes Buildings, Cape Town.
1899 Mason, W. G., *B.Sc.*, *F.H.A.S.*, Elsenburg, Mulder's Vley, C. C.
1899 Masson, J. L., Surveyor-General's Office, Maritzburg.
1896 Mayer, C., Stellenbosch, C. C.
1901 Meacham, C. S., Mariedahl, Newlands, C. C.
1897 Meiring, I. P. van H., Worcester, C. C.
1901 Melvill, E. H. V., Johannesburg.
1903 Menmuir, R. W., *A.M.I.C.E.*, Woodstock, C. C.
1902 Mennell, F. P., Rhodesian Museum, Bulawayo.
1899 Millar, A. D., 298, Smith Street, Durban, Natal.
1903 Milligan, A., D'Urban.
1900 Milner, H. E., *Viscount*, *G.C.B.*, *G.C.M.G.*, Johannesburg.
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1892 Muir, T., *C.M.G.*, *LL.D.*, *F.R.S.*, Department of Education, Cape Town.
1902 Muirhead, J. M. P., *F.S.S.*, Selwyn Chambers, St. George's Street, Cape Town.
1903 Muller, H. J., Willowmore, C.C.
1903 Nobbs, E., *Ph.D.*, Department of Agriculture, Cape Town.
1901 Noorden, P. M. van, Willowmore, C. C.

1902 Notcutt, H. C., *B.A.*, Victoria College, Stellenbosch, C. C.
1899 Oakley, H. M., The Colonnade, Greenmarket Square, Cape Town.
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1902 O'Neil, *Rev.* J. A., *S.J.*, Dunbrody, Uitenhage, C. C.
1900 Orpen, J. M., Bulawayo.
1899 Pakeman, *Capt.* A. E., East London, C. C.
1902 Palmer, *M.A.*, *LL.B.*, Cape Town.
1901 Payne, E., Sir Lowry Road, Cape Town.
1903 Payne, H., *A.M.I.C.E.*, South African College, Cape Town.
1903 Pearson, H. H. W., South African College, Cape Town.
1885 Péringuey, L., *F.E.S.*, *F.Z.S.*, South African Museum, Cape Town.
1901 Perry, T. W., Public Works Department, Cape Town.
1902 Pickstone, H. E. V., Groot Drakenstein, Paarl.
1899 Piers, C. E., *M.D.*, Camp Street, Cape Town.
1901 Proctor, J., College House, Cape Town.
1895 Purcell, W. F., *Ph.D.*, *M.A.*, South African Museum, Cape Town.
1899 Queckett, J. F., *F.Z.S.*, the Museum, Durban, Natal.
1894 Raffray, A., Consul-General for France, Cape Town.
1901 Reunert, T., *M.I.C.E.*, Johannesburg.
1896 van der Riet, B., *Ph.D.*, *M.A.*, Victoria College, Stellenbosch, C. C.
1900 Ritchie, W., *M.A.*, South African College, Cape Town.
1902 Ritso, B. W., *F.G.S.*, Public Works Department, Cape Town.
1898 Rix Trott, H., Port Elizabeth.
1892 Roberts, A. W., *D.Sc.*, *F.R.A.S.*, Lovedale.
1901 Roberts, R. O. W., Town House, Cape Town.
1901 Robertson, J., Boys' High School, Wynberg.
1900 Robertson, W., *M.D.*, Department of Agriculture, Cape Town.
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1899 Rohden, M. F., Oudtshoorn.
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1890 Ryan, P., Rosebank, C. C.
1895 Saunders, H. P., Arderne's Bldgs., Cape Town.
1890 Schönland, S., *Ph.D.*, *M.A.*, Albany Museum, Graham's Town, C. C.
1896 Schreiner, *Hon.* W. P., *K.C.*, Lyndale, Newlands, C. C.
1878 Schunke-Hollway, H. C., *F.R.G.S.*, Simondium, Paarl, C. C.
1895 Schwarz, E. H. L., *A.R.C.S.*, *F.G.S.*, South African Museum, Cape Town.
1896 Sclater, W. L., *M.A.*, *F.Z.S.*, South African Museum, Cape Town.
1901 Shepperd, H. P., Stellenbosch, C. C.
1877 Silberbauer, C. F., 4, Liesbeek Villas, Rondebosch.
1896 de Smidt, H., *B.A.*, The Treasury, Cape Town.
1877 Smith, the *Hon. Sir* C. Abercrombie, *M.A.*, Wynberg, C. C.
1901 Smith, *Rev.* E. W., Aliwal North, C. C.
1902 Smith, *Hon.* G. D., Cape Town.
1900 Stanford, W. E. M., *C.M.G.*, Umtata, C. C.
1903 Stevenson, Sinclair, *M.D.*, Rondebosch, C. C.
1897 Stewart, C. B., *B.Sc.*, Meteorological Dept., Cape Town.
1903 Stewart, T., *F.G.S.*, *M.I.C.E.*, St. George's Chambers, Cape Town.
1895 Stoney, W. W., *M.D.*, Kimberley, C. C.
1903 Stott, C. H., *F.G.S.*, Pietermaritzburg, Natal.
1899 Struben, A., Westoe, Mowbray, C. C.
1897 Sutton, J. R., *B.A.*, P.O. Box 142, Kimberley, C. C.

1898 Tennant, David, 102, Wale Street, Cape Town.
1902 Thomson, A. E., *M.D.*, Burg Street, Cape Town.
1895 Thomson, W., *M.A.*, *B.Sc.*, *F.R.S.E.*, University Chambers, Cape Town.
1903 Thomson, J. G., *F.L.S.*, South African Museum, Cape Town.
1903 Toit, du A. L., *F.G.S.*, South African Museum, Cape Town.
1882 Tooke, W. Hammond, Dept. of Agriculture, Cape Town.
1903 Travers-Jackson, G. H., P.O. Box 365, Cape Town.
1896 Tredgold, C. H., *B.A.*, *LL.B.*, P.O. Box 306, Bulawayo.
1896 Turner, G., *M.D.*, Government Buildings, Pretoria.
1897 Versfeld, J. J., *F.L.R.C.S.*, Stellenbosch, C. C.
1877 de Villiers, The *Right Hon. Sir* J. H., *K.C.M.G.*, *P.C.*, Wynberg, C. C.
1900 Waldron, F. W., *A.M.I.C.E.*, Public Works Dept., Cape Town.
1900 Walsh, A., Cape Town.
1903 Warren, E., *D.Sc.*, The Museum, Maritzburg.
1893 Westhofen, W., *M.I.C.E.*, Public Works Dept., Cape Town.
1878 Wiener, L., Newlands, C. C.
1898 Wilman (Miss), M., Kenilworth, C. C.
1900 Wilson, H. F., *M.A.*, Groenhof, Bloemfontein.
1897 Wood, J. Medley, Berea, Durban.
1903 Wilson, Marius, *M.D.*, Cape Town.
1902 Young, E. W., *M.I.C.E.*, Rondebosch, C. C.
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TRANSACTIONS

OF THE

SOUTH AFRICAN PHILOSOPHICAL SOCIETY.

AN INTRODUCTION TO THE STUDY OF SOUTH AFRICAN RAINFALL.

By J. R. Sutton, M.A., F.R.Met.S.

(Read December, 1903.)

This paper is to be regarded as the fifth of the meteorological series planned some years ago, four of which have appeared in previous volumes of the *Transactions* of the South African Philosophical Society.

The following materials are available for a discussion of the rainfall of Kimberley:—

1. Monthly totals 1875, 1877–1902, by F. W. Matthews.
2. A complete daily register, 1884–1897, by the late G. J. Lee.
3. A complete daily register, 1880–1890, saving a gap in 1884, by the late L. and S. A. Exploration Company, taken for the Meteorological Commission; also nearly complete monthly totals from the same gauge, published in the Annual Reports of the Meteorological Commission, 1880–1900.
4. Monthly totals, 1885–1900, by the Gaoler, taken for the Meteorological Commission.
5. A complete register, 1894–1902, by J. R. Sutton.
6. Nearly complete returns within the last five years from gauges established at the different mines owned by the De Beers Company.
7. Occasional returns from various sources.

Of these the first is in many respects the most important, as it is the most extensive and complete. The record shows internal evidence of having been well and faithfully kept. The gauge has,

however, what might be called a "roof" exposure, at an elevation of about 15 feet. This seems to have resulted in a small loss in the catch. Still an elevated gauge at Kimberley would not lose so great a percentage of the total fall as one at the same altitude in England, since our winds are lighter, and the average size of the raindrops much greater. Small droplets are readily carried by strong winds, as is proved by the "salt rain" (really sea spray) occasionally reported from different parts of inland England.* The Matthews gauge is a 5-inch Symons's early pattern.

No. 2 had also a roof exposure at nearly the same height. The gauge is an 8-inch Meteorological Office pattern. In earlier years the catch was entered to the ninth decimal place! This unique effort seems to have been accomplished by weighing the catch and converting ounces and grains into inches. But even if the mouth of the gauge had been accurately measured, the quantity of dust and rubbish collected would probably have been fatal to the trustworthiness of anything after the third decimal place. As a matter of experience, weighing is not to be recommended, with or without the extra decimals. "Weighing the water," said Horsley, "and reducing it from weight to depth, seemed pretty troublesome even when done in the easiest method." †

No. 3 is a Glaisher 8-inch gauge. Up to 1889, when the De Beers Company took over the business of the Exploration Company, it stood about 4 feet above the ground in a small courtyard behind the offices in Lennox Street. Now it is being used in the west end of Kimberley. I have some indistinct idea that the mouth of the gauge was said to be slightly too large, although it would be less surprising to be told that it had become too small, such being the certain ultimate fate of every gauge; for with a given perimeter a circle encloses the greatest area, and therefore any deformation of the rim of a gauge means a reduced area of catch. For a nice proof see Halsted, *Elements of Geometry*, p. 162.

Like a number of other gaols in the country, the rainfall reported by No. 4 is less than that reported outside. The inference that rain does not therefore fall upon just and unjust alike is plausible but incorrect. The true explanation is that the lighter rains are ignored by the observer.

No. 5 is an 8-inch ordinary gauge, mounted with its rim 3 feet above the ground. The observations with this have been supplemented by the hourly totals of rain caught in a large evaporation

* See *e.g.*, *Phil. Trans.*, 1704, *passim*; Luke Howard, *Appendix to Barometrographia*, part 2, p. 16a.

† *Phil. Trans.*, 1723.

tank. These are generally too small as compared with the gauge, for reasons to a large extent obscure.

In consequence of the great local variation in the falls of rain, a number of 5-inch Snowdon gauges were set up in 1897 at the different mines and on some of the farms owned by the De Beers Company. The records were in many cases broken during the late war, and all the outside gauges taken away by the Boers. These gauges were all placed at the same height above the ground as the Kenilworth gauge, but they are mostly in a more open situation. This may be partly the reason why their catch is so frequently less than that of Kenilworth.*

Tables 1–12 give a complete history of rainfall at Kimberley from 1877–1902. The daily amounts for 1877, 1888, 1889, and part of 1884, were kindly given me by Mr. Matthews; 1880–1883, the remainder of 1884, with 1885, are from the Exploration Company's register; 1886–1897 are from the Lee register; 1898–1902 are from the Kenilworth register. Thus the history deals almost exclusively with the records of 8-inch gauges,† one half giving the rainfall near the ground, the other half at a height of 15 feet.

It has been usual at Kimberley to reckon the fall up to 8 a.m. on the last day of each month, entering the separate items to the date of measurement; but because it is preferable to give the fall up to 8 a.m. on the 1st of the following month, I have rearranged the monthly totals accordingly; and, so as not to disturb previous dates, made a rain month of 31 days extend from the 2nd to the 32nd. The totals in the last column of the historical Tables give the number of days, and the total fall for each date, in twenty-six years. If annual averages are required they may be obtained after division by 26.

It appears from these Tables that March is the wettest and July the driest month, the increase or decrease from one to the other being gradual. Although the total fall is less in February than in January, February is really the wetter month by an average of ·07 inch per day, on account of the fewer days it contains. There

* The student may with profit consult Heberden, "On the different quantities of Rain which appear to fall at different heights, &c.," *Phil. Trans.*, vol. lix. p. 359 (1769); Barrington, "Experiments made . . . to ascertain the different quantities of Rain . . . at different heights," *Phil. Trans*, vol. lxi. p. 294 (1771); and chiefly, on the general question, Hann, *Lehrbuch der Meteorologie*, p. 296 Cleveland Abbe, "Determination of the true amount of Precipitation, &c.," *Bulletin No.* 7, *F. D.*, U.S.A. Dept. of Agr.; also G. Dines, "Difference of Rainfall with elevation," *British Rainfall* (1880). The other literature on the subject is of enormous bulk, and often amazingly futile.

† Not that the size of the gauge makes any appreciable difference.

seems, however, to be a distinct tendency to wet and dry seasons characteristic of certain seasons. For example, the first half of February and the second half of November are notably deficient in quantity; also the latter half of June, the latter half of September, the fourth week of October, and the first half of December, are relatively wet. The absolutely wettest time is during the last week of February; the driest during the first week of August.

Of the accidental variations we have some remarkable cases, due chiefly (probably) to the shortness of the record. A good example is found in the twenty-four hours ending at 8 a.m. February 9th. In the whole twenty-six years there was not a single shower on this date so great as ·10 inch, and indeed only one shower of any importance on the 10th; the total fall for the two dates together in the whole twenty-six years only reaching three-quarters of an inch. But as it happens the rule for dry weather at this time breaks down in the present year, 1903, with ·45 inch—a greater fall for the date than is furnished by all the former twenty-six years put together. Still it is curious, to say the least, that February 9th is the driest day, and February 9th and 10th the driest two days, in sixteen consecutive weeks. On the other hand, the rule for each of the four dates, February 25th–28th, is for heavy rain in every other year. Dates upon which no rain at all is known to have fallen are only found between June and September; albeit too much stress should not be laid upon the apparent dryness or otherwise of particular dates in any record extending over less than fifty years, because, for one reason, the total rain as given for any date is not materially greater than the possible rain in twenty-four hours. Take, for example, the rain of September 17th. This, for at least a quarter of a century, from 1877–1901, seemed to be one of the driest of days, only one small fall of ·015 inch being on record. In 1902 came a change with the heaviest day's rain known here (*i.e.*, 4·52 inches), making September 17th at one jump the wettest date in six months. This is a heavier fall than some rainfall maxims allow for. For example: "The extreme percentage of the mean annual rainfall which may be expected on any one day is, with a mean fall of 20 inches, 16 per cent. . . ." * For the same mean annual fall E. M. Eaton gives 20 per cent.† The Kenilworth fall in question is, however, nearly 25 per cent. of the annual mean. Moreover, in India there are stations where the fall in one day has exceeded the annual mean.‡

* *British Rainfall*, 1867.

† *Symons's Met. Mag.*, 1878, p. 13.

‡ See Blandford, "Climates and Weather of India," pp. 64, 266.

The complete Matthews register of monthly totals is given in Table 13, and for comparison the yearly falls according to the Lee, Sutton, and Meteorological Commission registers. We may extract the following set of comparative annual averages :—

1877–1902 (26 years).	
By Tables 1–12	18·47 inches.
Matthews	17·81 ,,
1884–1897 (14 years).	
Matthews.....	18·08 inches.
Lee	18·53 ,,
Meteorological Commission	19·63 ,,
1894–1902 (9 years).	
Matthews.....	18·84 inches.
Sutton	18·99 ,,

It will be gathered from the comparative results of Table 13 that, even after making allowances for faulty exposure, the annual fall of one part of Kimberley may differ greatly from that of another. Thus in 1897 the fall at different gauges varied between a little more than 8·75 inches to a little less than 14 inches, most of the variation occurring in March. Also in 1902 the Kenilworth fall was upwards of 4·5 inches greater than that at the De Beers mine. The actual annual extremes shown by Table 13 range between 8·85 inches (in 1897 at Kenilworth) and 34·23 inches (in 1891 at the Exploration Company's gauge), a total range of more than 25 inches. This makes the maximum annual total nearly four times the minimum. There is, moreover, a register for Du Toit's Pan showing a much greater range, from 7·79 inches in 1878 to 37·46 inches in 1881, making the maximum nearly five times the minimum.* Without absolutely denying the truthfulness of these exceptional amounts, they should at any rate be received with caution. A minimum of 7·90 inches in 1892, reported from the Kimberley gaol, is undoubtedly too small, the number of rainy days being returned at twenty-nine!

It is interesting to compare the annual range of rainfall for Kimberley with that of some other places. Sir Charles Todd gives very full and clear information under this head for South Australia.†

* *Report of the Met. Com.*, 1880, 1881.

† *Met. Obs. made at the Adelaide Observatory*, &c., 1899.

The following are worth attention:—

Port Darwin.....	42·44	inches to	81·72	inches.
Alice Springs	5·39	,,	27·21	,,
Parallina	1·71	,,	20·41	,,
Adelaide	13·43	,,	30·87	,,

At Leon, Estado de Guanajuato, Mexico, the range is from 12·39 inches to 35·79 inches.*

At Algiers the range is from 17 inches to 51·45 inches.†

At Cordoba, Argentine, from 19 inches to nearly 40 inches.‡

In India we have Calcutta, with an annual average of about 65 inches, and a range from 38·5 to 98·5; Cawnpore, with an average of 32·3 inches, and a range from 7·1 to 60·7; Kurrachee, with an average of 7·6 inches, falling sometimes below half an inch, and rising sometimes to 28 inches; Bombay (Colaba), with an annual average of 74 inches, and a range of 79 inches from 35·9 to 114·9.§

At Durban the range is from 27·24 inches to 71·27 inches; at Port Elizabeth from 10·41 to 33·59; at Cape Town from 17 to 41.

Therefore, while the range at stations near the coast of South Africa is not materially different from that of other coasts, the range at Kimberley is relatively less than that of the inland stations of Australia and India, and greater than those of the interior of South America.

Table 14 has been designed to show the total rain of Tables 1–12 in twenty-four equal parts of a year of fifteen days each. To obtain this the total fall of February 29th has been increased in the ratio 5 : 26, there having been five leap-years in the period under review. The twenty-four quantities so obtained may be expressed in inches by the formula:—

$$\begin{aligned} R = 483{\cdot}024 &+ 18{\cdot}012 \sin (n15^\circ + 70^\circ) \\ &+ 4{\cdot}428 \sin (n30^\circ + 340^\circ{\cdot}8) \\ &+ 9{\cdot}764 \sin (n45^\circ + 339^\circ{\cdot}8) \\ &+ 2{\cdot}028 \sin (n60^\circ + 211^\circ{\cdot}4) \\ &+ \ldots\ldots\ldots\ldots \end{aligned}$$

The relative magnitudes of the third and fourth terms of this formula are worth notice.

Table 15 epitomises Tables 1–12, giving for each month the number

* M. Leal, "Clima de Leon," *Mem. Soc. Alzate*, t. xii. p. 15.

† A. Thevenet, "Essai de Climatologie Algérienne."

‡ W. G. Davis, "Clima de Cordoba," *Anales Ob. Met. Arg.*, t. ix. (2) p. 299.

§ *Indian Met. Mem.*, vol. xiv.

of days of rain, and the average number per annum, in twenty-six years; the total fall in twenty-six years, and the annual average; the average per day, and the average per rainy day; the greatest fall on record, in one day, and one month; also the chance of a rainy day in any coming month. It seems that a fall exceeding an inch in twenty-four hours is not as a rule to be anticipated in June, July, or August, nor a month's rain exceeding 2 inches. The heaviest falls have occurred in the spring months, a single day's rain not infrequently making the month's total equal to that of the summer months. It is curious that the rate of fall should be greatest in September. There seems to be some indication of maximum rates at the equinoxes and solstices.

Table 16 gives the number of daily rainfalls of given quantity in the twenty-six years—the daily falls in 16A, and the monthly in 16B. It appears from this that upon nearly one-half the total of rainy days the fall is less than one-tenth of an inch. It must be remembered, however, that many of these small rains are associated in some way with the heavier falls, *i.e.*, they precede or follow wetter days. October is remarkable for the relatively great number of days upon which the fall is between ·5 inch and 1 inch. In September, on the other hand, it seems to be the rule for twice as many heavy falls above 1 inch as below. In fact, of the whole September fall of something less than 24 inches in twenty-six years, nearly 14 inches, or 58 per cent., fell in the seven days upon which the fall exceeded 1 inch per diem; whereas only 8·5 per cent. fell in the three days upon which the fall was between ·5 inch and 1 inch. In October more than 40 per cent. of the rain comes in showers of ·6 inch (more or less) each.

Some individual tendency to periodicity is indicated by rains of different intensity: good rains, say exceeding ·5 inch, have a maximum frequency in March and a minimum in July; which happens to be the case also for very light showers. But rains of between ·1 inch and ·5 inch have a maximum frequency in February and a minimum in August.

In Table 16B the most interesting month is October. In this month it is more than an even chance that the rain will be between 1 and 2 inches in amount. There is only one instance on record in which the rain for the month exceeded 2 inches, the excess falling in one day. The last column shows that in March and October the monthly rain is as often above the average as below.

There is not yet sufficient material available here to enable us to single out the rains of the different types from the ombrometric

statistics. To do so successfully would require all the accumulated records of a weather bureau, although it may be possible later on to introduce some facts of interest in this connection. At present it may perhaps be taken as a working basis that the greater part of our rain falls in thunder-squalls and secondary cyclones, no great quantity coming in cyclones proper nor with straight isobars.

Table 17 gives the diurnal variation of rainfall at Kenilworth, in quantity and duration, both in whole totals for six years (1897–1902), month by month, and in annual averages. There was not a separate recording rain-gauge at this station during this period, and therefore the values have been mostly reduced from the automatic records of the evaporation tank. The yearly average quantities show a principal maximum at 4.30 p.m., and a principal minimum at 9 a.m.—being thus very nearly the inverse of the barometric phases. There are points of relationship with the diurnal oscillation of the barometer, as well as with the horary dewpoints. The phases of frequency are interesting because the maxima tend to fall earlier, and the minima later, than those of quantity. The last line of Table 17 gives the average fall for each hour of rain at different times in the day. This indicates that the rate of fall is lightest an hour or so after sunrise, and heaviest just before sunset, the increase of rate during the daylight hours being gradual. During the night hours there are considerable irregularities, with a strong tendency to a long-drawn-out maximum between XXIII. and III.

Table 18 shows the diurnal variation of rain for different seasons in portions of the total fall in six years; the total hours; and the average rate in each rainy hour. At the foot of the Table is given a summary showing how the seasonal variation is distributed between day and night, *i.e.*, from VI.–XVIII., and from XVIII.–VI., respectively. This proves that, saving the spring months (August–October), the greatest quantity of rain falls at night. In the summer it rains as often by night as by day; but in the winter there are half as many rainy hours again at night as there are by day. The rate of fall per rainy hour, however, is pretty much the same night and day, excepting in the spring. Putting all the seasons together, we find the quantity rather the greater at night, but the number of hours still greater, so that on the whole the rate of fall is greater by day.

Table 19 is inserted for comparison with Tables 17 and 18. It shows:—

1. Thunder and Thunderstorms.

2. Lightning unaccompanied by audible Thunder.
3. Thunder, Thunderstorms, and Lightning, all together.

The numbers are got from eye-observation. They cannot pretend to any completeness, particularly of lightning during the night. They show all that was seen or heard of this kind of electrical manifestation, but it is certain that many hours of it must have escaped notice. Still, they probably give a fairly good rough idea of the diurnal variation, at any rate between VI. and XXIV. A feature of special interest in the Table is the curious slackening in the frequency of thunderstorms between XVI. and XVII. Since thunderstorms evidently tend to a maximum about the time of sunset, we have at once a reason why the greatest rate of rainfall should come about this time.

Table 20 gives the most important harmonic constants in the diurnal curve of rainfall at Kenilworth, counting from 0h. 30m. a.m. The resemblance of the annual and semi-annual waves of both quantity and frequency to the same waves of barometric pressure inverted is very strikingly exhibited in the epochs. Attention should also be directed to the small fluctuation in the epoch of the second term of rain-frequency at all seasons, its departure from the mean never much exceeding half an hour. It is important to compare this fact with the resemblances between the corresponding terms of barometric pressure and vapour tension mentioned in previous papers of this series.* Seeing that there are not any mountains on the tableland to turn the horizontal air currents upwards, and that the air when it rises must do so of itself, the importance of this result in its bearings upon the theory of the semi-diurnal oscillation of the barometer will be obvious.

The amplitudes are of some interest. In the hours for the year the fourth harmonic term is practically as great as the third. But in the case of quantity the fourth is very much smaller than the third. Therefore the rainfall of six hours' period is very light. The first term is the greatest at all seasons, but the relative magnitude of the other three varies through the year. In the spring the second term almost vanishes, while the fourth term is large. In the summer the second term is large.

The harmonic constants of thunderstorms bear a strong family likeness to those of rain, particularly the summer frequency of the latter to the mean of the former. It is evident that a large proportion of the summer rain falls in thunderstorms, that of other classes being largely represented by the fourth term.

The diurnal variation of thunderstorms is probably a general

* See "An Elementary Synopsis, &c.," *Trans. S. A. Phil. Soc.*, vol. xiv., p. 185.

phenomenon subject to local influences. For the purpose of comparison with the Kenilworth numbers I venture to quote the constants given by Riggenbach for Basle and Vienna.* Those for Basle are computed from hourly statistics of 1473 hours of thunderstorms observed between 1826 and 1888, supplemented by 171 others of which the duration and time of day is somewhat doubtful. Those for Vienna are quoted from Hann. Both the Basle and Vienna amplitudes are reduced to proportional parts of a thousand, the Kenilworth amplitudes are not. Riggenbach notes the near resemblance of certain of the phases of the two European stations. As it happens, the first two phases of the Kenilworth formula fall about as much later than Basle as Basle is than Vienna. Some correction, however, will have to be made for a departure from local time at Kenilworth of about seven minutes, the longitude of this place being about 24° 27′ E., while the time system is reckoned from the meridian of 22° 30′ E. Whether the Basle and Vienna constants refer to local or zone time I do not know.

It is important to determine in what manner particular wind-directions are associated with the monthly rainfalls. To do this, the monthly average number of hours of wind blowing in each direction during the six years 1897–1902 has been first determined from the automatic records taken at Kenilworth. The departures from these monthly means are then tabulated for each month, and it is also marked whether the concomitant rainfall is greater or less than the mean. Such departures of monthly wind-direction from the normals are then arranged into two sets according as the accompanying rain was greater or less than the normal rainfall. The result is condensed into Table 21, for each quarter of the compass. A plus sign indicates that in any set, for any month, there were more hours of wind than the average, a minus sign that there were less hours. For example, in January, with deficient rainfall, the number of hours of wind from N.–E.N.E. was thirteen hours short of the average; whereas when the rain was in excess the wind from the same quarter was twenty-four hours greater than the average. It appears from this that, taking the year as a whole, in the more rainy months the winds with an easterly component increase; those from the west increasing in dry months. In individual months there are some exceptions to the rule: in December, *e.g.*, a rainy month and an increase of wind from the north-west go together; in October the increase is from the south-west; in June and July the increase is with the winds having a southerly

* A. Riggenbach, "Resultate aus 112 jährigen Gewitteraufzeichnungen in Basel," T. viii., 1889.

component. A miniature monsoon effect is suggested by this. For the greater part of the year our rain seems to be associated with surface winds having an easterly component; but during midwinter with surface winds from the south. This seems to furnish a link between the summer rains of Durban and the winter rains of the Cape Peninsula. At the same time two or three circumstances must be borne in mind: First, that it does not follow that these particular prevailing directions bring the rain, seeing that they may be as much an effect as a cause; second, that the cloud currents generally spring from points lying somewhere between north and west—clouds of the cirrus type coming more from the west, those of lower levels more from the north, of the mean direction; third, that as a rule the particular wind-direction associated with abundant rain, characteristic of any month, is the dominant normal wind of that month—that is to say, with abundant rain the normal prevailing wind prevails yet more; or, in other words, the rainfall decreases with the deviation of the vane from its normal position. This is a curious commentary on a previous result, "that, relatively to the normal curve, the cloudiness of the sky increases with the deviation of the vane from its normal position."* The cloud result, however, applies to the diurnal variation of the wind, while the rain result applies to the mean direction for the month. A noteworthy consideration is that whereas there were two months having a rainfall less than the mean to every one having a rainfall greater, in the six years under review, more deficient months have been included in forming the wind-averages than abundant ones, and therefore a certain amount of preconceived bias towards dryness has entered into the ratios. In passing it may be mentioned that the same bias is some drawback to the greater number of meteorological statistics in which one element has to be compared with another. It is not unlikely that deviations from the median, rather than from the mean, would give better comparative results.†

I have not yet made any experiments for the purpose of determining the temperature of falling rain, nor indeed do I yet know of a likely method.‡ But it may be roughly estimated, in proportionate numbers, from the consideration that in heavy falls the temperature of air, rain, and dewpoint, must tend to a common

* "Winds of Kimberley, *Trans. S. A. Phil. Soc.*, vol. xi., pt. 1, p. 92.

† See Hann, "Handbook of Climatology" (Ward's edition), p. 24; Merriman, "Method of Least Squares," 8th ed., p. 210; Lupton, "Notes on Observations," 44.

‡ See, however, Hann, *Lehrbuch der Met.*, p. 303.

equality. Acting upon this principle the temperature of the dew-point has been tabulated, in each month, at the end of any hour in which there was a rain exceeding ·10 inch. The results are arranged in Table 22 : Column 1 contains the months; Column 2 the mean monthly temperature of the air for the five years 1898–1902; Column 3 the mean monthly temperature of the dewpoint; Column 4 the mean temperature of the dewpoint immediately after rain, for each month; Column 5 the frequency, *i.e.*, the number of observations from which Column 4 has been deduced. We may from these results form some idea of the altitudes from which the rain has fallen. For taking the adiabatic rate of cooling of the air as 1°·6 F. for each 300 feet of ascent, and the lowering of the dewpoint as 0°·3 for the same space due to the expansion of the air, we have this formula for the height h of the lower surface of the rain clouds—

$$h = 3000(t - d)/13,$$

where t is the normal temperature of the air and d that of the dew-point after rain at the earth's surface.* Whence we get the relative heights of the rain clouds in Column 6. Of course these values can make no claim to any great precision, because while on the one hand the falling rain must notify the temperature of the air through which it passes, and thus also the mean temperature of the month, on the other hand it is certain that the rain mostly comes not so much from the cooling of ascending currents of moist air as from horizontal streams bringing moisture from the ocean. The average of Column 6 for the summer half, September to March, is 2,560 feet, that for the winter 1,060 feet. The August value, being obtained from only one observation, is of no great consequence. That October has a lower cloud level than either September or November is probably a fact, and may be directly connected with the absence of very heavy thunderstorms characteristic of that month, so plainly indicated in Table 16. Moreover, the October clouds tend, perhaps more than those of any other month, to a stratiform type, suggestive of the plane of contact of two humid air-strata at different temperatures.† The smallness of the April value is remarkable.

In the absence of direct measures the formula just quoted may be used for the purpose of approximately determining the altitudes at Kimberley of clouds generally. It gives a monthly average series ranging from upwards of 6,000 feet in November to 3,000 feet in April—this last value confirming the April minimum of Table 22. A useful development is a comparison between the mean monthly

* W. M. Davis, "Elementary Meteorology," p. 163.

† See the remarks by F. Waldo, "Modern Meteorology," p. 255.

amounts of cloud and the corresponding computed mean altitudes of the lower plane of condensation. In Table 23 this is done in two ways: First, for each month of the five years 1898–1902 the mean monthly amount of cloud is tabulated in order of magnitude, followed by the corresponding computed altitude of the plane of condensation; next, the process is reversed, the computed altitudes being tabulated in order of magnitude followed by the corresponding amounts of cloud. For example, taking the mean results for January, we have in illustration of the first scheme:—

	Year.	Order.	Cloud.	Plane.
January	1898	A	59 per cent.	2,838 feet
	1899	B	45	5,538
	1900	C	38	5,331
	1902	D	31	5,123
	1901	E	30	6,438

And in illustration of the second—

	Year.	Order.	Plane.	Cloud.
January	1898	F	2,838 feet	59 per cent.
	1902	G	5,123	31
	1900	H	5,331	38
	1899	J	5,538	45
	1901	K	6,438	30

The double process is necessary because a particular month may have the same cloud percentage, but different cloud altitudes, in different years.

It appears from Table 23 that, generally speaking, the average altitude of the first plane of condensation will be greater as the cloudiness of the sky is less; and conversely. A moment's thought, and a glance at the Table, will show that this is not contradictory to the other result that the plane of condensation is lower in winter (when the percentage of cloud is small) than it is in summer (when the percentage of cloud is relatively great). The statement, however, is not a law in the sense that a great percentage of cloud necessarily implies a low cloud level. For obviously the prevailing cloud of any assigned month may be cirrus, or it may be stratus, or what not. But in the long run, when sufficient observations have been accumulated to give the averages their chance, the statement may be exact enough. As we might expect, then, in very dry weather the sky will be clearer than when there is much

moisture in the air; and clouds, when they do form, must float at a much higher level.

Table 24 gives the mean annual complements of the dewpoint for each hour of the day, and the corresponding computed altitude of the first plane of condensation. According to this the diurnal variation ranges from about 2,000 feet at VI. to 7,000 feet at XV. The minimum altitude here may be somewhat too high, while the maximum is probably quite 400 feet too low. The Blue Hill observations show that up to about noon the computed and observed altitudes of cumulus, strato-cumulus, stratus, and nimbus, are not appreciably unlike; but after noon the observed altitudes become greater than the computed, reaching a maximum excess of 500 feet between XV. and XVI.* The explanation seems to be that the upward impetus of the warm air currents continues for some time after the temperature has begun to fall at the surface of the earth.

Table 24 gives also the monthly variation of the computed altitudes of the first plane of condensation at VI. and at XV. We see from this that the VI.-curve is the flatter, its amplitude being less by some 1,200 feet, and the actual minimum curve is flatter still. The greatest monthly mean computed altitude at either of the two selected hours in the five years considered was in November, 1900, with 10,250 feet, the least in April, 1899, with 690 feet, the former of course at XV. and the latter at VI. It may not be out of place to remark here that since the cloudiness of the sky only averages about 29 per cent., and the duration of sunshine is upwards of 76 per cent. of the optimum, the warm air currents do not in the majority of instances rise to the condensation level.

We have now to consider the position of Kimberley in the general scheme of South African rainfall. The principal published information suitable for this purpose will be found in the Annual Reports of the Meteorological Commission, where monthly totals and the maximum fall in each month only are given, derived from 300 (odd) gauges distributed throughout South Africa. The quality of the material is not of the best, although it has undoubtedly improved of recent years. Buchan has made a useful summary of the whole of the monthly totals printed in the reports of the ten years 1885–1894.† He deals with 278 stations, of which about one-half have a complete record; the other half having a shorter history of two to nine years.

Monthly averages for 160 stations having, generally speaking, com-

* "Blue Hill Met. Obs.," in the *Harvard Annals*, vol. xlii., Part 1, p. 124. The discussion explains it the other way about.

† "A Discussion of the Rainfall of South Africa," 1897.

plete records for not less than seventeen or eighteen years, have been computed and arranged in Table 25. In the few instances made use of where the record is for a less number of years, the station is inserted because the area is badly represented or because of some importance in the site. The material comes chiefly from the pick of the annual reports of the Meteorological Commission for the years 1880–1901. Of the rest, the Kimberley record, as already mentioned, is from private registers; the Bloemfontein record was taken mostly from a register printed in a local newspaper; the Natal records are from the very excellent annual reports issued by the Durban Observatory, supplemented by some MS. monthly totals kindly sent me by Mr. Nevill.

In forming Table 25 I have availed myself largely of Buchan's work, simply combining in most of the cases his ten-year normals with the results for twelve additional years. This course was justified by an occasional test of the same normals. The rainfall areas I., II., III., IV., . . . of the Meteorological Commission's arrangement have been retained for the sake of continuity, although it is not easy to see why they were ever adopted.* The only attempted improvement has been to divide all the areas which seemed to extend too far east and west into two. A comparison between the Commission's map and its modification given at the end of this paper, together with an examination of the rainfall of some of the Karroo areas, will show the necessity for such a plan. Our subdivision raises the number of areas from fifteen to twenty. For each of these the mean rainfall has been computed, and approximate angles and coefficients in the sine series determined—only approximate because the months vary in length. These last appear in Table 26, wherein V_1, V_2, V_3 are the epochs; u_1, u_2, u_3 the amplitudes; u'_1, u'_2, u'_3 the amplitudes in parts per thousand of the mean monthly rainfall. We shall return to a consideration of these constants presently.

So far as these 160 stations go, Section I. (the Cape Peninsula) has the most copious fall, with an average of over 40 inches per annum; Section XV. (Natal) coming next with nearly 36 inches. The western division of Section IX. (Northern Border) is the most arid, with an average of less than 6 inches. It is to be remembered, however, that the sectional average results depend to a great extent upon the number of gauges in a given area, and their position. Generally the number of good records throughout

* The latitudes, longitudes, and altitudes, are from the latest Reports of the Met. Com. Some of these are doubtful: Uniondale, Kleinpoort, and Glenconnor, in Section V., for example.

the Colony seems to vary directly as the intelligence of the population.*

Of the individual stations dealt with, Waai Kopje, on Table Mountain, has the most lavish rainfall. But there are stations close by with more. The absolutely wettest place known in South Africa is probably Maclear's Beacon, also on Table Mountain, with an average annual fall for the seven years 1894–1900 of 86·81 inches, and a variability from 69·14 to 105·85 inches per annum.† Particularly wet stations are Evelyn Valley, with an annual average of 59·50 inches; Hogsback, with 47·49 inches; Lower Katberg, with 43·20 inches; Perie Forest, with nearly 40 inches (these four are in Section X.); Ceres (Section II.), with 39·69 inches; Storms River (Section IV.), with 42·52 inches; stations in Basutoland (Section XIII.), with 30–40 inches; parts of Natal, with 40 inches more or less.

The driest station south of the Orange River seems to be Port Nolloth (Section III.), with only 2·5 inches per annum, ranging from ·45 inch to 5·35 inches. Other dry stations are: Garies, with 5·66 inches; Van Rhyn's Dorp, with 6·20 inches; Matjesfontein (Section VI. W.), with 6·33 inches; Middlepost (Section VIII. W.), with 5·20 inches; and all the stations forming Section IX. W., Pella being the most prominent, with 3·31 inches.

Of adjacent stations exhibiting great contrasts we have the Zwartberg Pass, 24·70 inches, a very few miles from Prince Albert, 9·15 inches; Alicedale, 16 inches, not far from Grahamstown, 27 inches; Evelyn Valley and Thomas River only 2′ of longitude and 3′ of latitude apart, and the rainfall of the former nearly three times that of the latter; and of course the various places in the Cape Peninsula. These last resemble, on a smaller scale, the contrasts between the wettest and driest parts of England.‡

With few exceptions the averages of Table 25 are less than Buchan's, the mean difference being probably at least 2 inches. Undoubtedly Buchan's normals include some particularly wet years.§

* The lack of rainfall records in Natal until recently is remarkable, and does not confirm the generalisation. It must have been thought that because the best meteorological work in South Africa was being done at the Durban Observatory, potential observers were relieved of the responsibility of keeping registers.

† T. Stewart, "The Rainfall of the Cape Peninsula," a paper read before the S. A. Phil. Soc., Feb. 6, 1901.

‡ There does not seem to be any tendency in South Africa to a simple relationship between rainfall and altitude, as is sometimes found in more truly mountainous countries.

§ See also D. E. Hutchins, "Rainfall of S. Africa," in *C. G. H. Agricultural Journal*, Dec. 9, 1897.

Table 26 enables us much better than Table 25 to subdivide South Africa into suitable rainfall areas. Broadly these are—

1. Area of winter rains.
2. Area of summer rains.
3. Area of spring and autumn rains.

The characteristic formulæ of these give :—

1. $V_1 = 280°$, more or less ; $u_1 > u_2$ or u_3.
Sections I., II., III., belong to this class.)

2. $V_1 = 60°–100°$; $u_1 > u_2$ or u_3.
(Sections XV., XIV., XIII., XII., XI., X., IX. E., VIII. E., VII. belong to this class.)

3. $V_1 = 180°$ or $360°$; $u_2 > u_3$ or u_1.
(Sections IV. E., IV. W., V. W., VI. W., belong to this class.)

But there is not really any abrupt transition from one class to the other; and the formula representing any section bears a certain affinity to those representing the areas round about it. Near the west coast the formulæ change the most rapidly.

Let us first consider the variation of the epoch in V_1 as the geographical position charges :—

Starting from Natal and travelling along the parallel of 30° S., we find that the angular magnitude of the epoch becomes smaller, *i.e.*, the phase times come later, from east to west. The variations are—

Area.	V_1.	Approximate Epoch of Maximum.
Section XV.	101°·5	Jan. 4
XIII.	85°·8	Jan. 19
XIV.....	77°·1	Jan. 29
IX. E.	67°·4	Feb. 7
IX. W.	54°·5	Feb. 20
III.	282°·0	July 5

Travelling west along a parallel somewhat to the north of 32° S., the variations are—

XII.	95°·8	Jan. 10
XI.	79°·2	Jan. 26
VIII. E.	67°·6	Feb. 7
VIII. W.	44°·1	Mar. 3
III.	282°·0	July 5

Travelling west along the parallel of 33° S., the variations are—

X.	95°·5	Jan. 10
VII.	77°·1	Jan. 29
VI. E.	66°·1	Feb. 9
VI. W.	19°·3	Mar. 28

But now we notice a remarkable fact. We have seen that the epochs come later as we travel east; they also come later as we travel northwards in the eastern districts; they also come later as we travel southwards in the western districts. Section XIII. is later than Section XII.; Section XIV. is later than Section X. But Section III. is earlier than Section I.; and Section IX. W., is earlier than Section VIII. W. It follows that the epoch of the first harmonic term is describing a curved orbit (if such a term may be permitted) with its concavity to the south. There is, for example, the following order:—

Area.	V_1.	Epoch of Maximum.
Section XV.	101°·5	Jan. 4
XII.	95°·8	Jan. 10
XIII.	85°·8	Jan. 19
XIV.	77°·1	Jan. 29
IX. E.	67°·4	Feb. 7
IX. W.	54°·5	Feb. 20
VIII. W.	44°·1	Mar. 3
VI. W.	19°·3	Mar. 28
V. W.	6°·5	April 10
IV. W.	329°·2	May 18

Fitting in with the same scheme are Sections X., VII., VIII. E., and Sections IV. E., V. E., VI. E., whose epochs come in corresponding sequence.

A similar line of inquiry with regard to the epoch of the second harmonic term shows either that the orbit is more complex, or that the monthly averages are not sufficiently near perfection to furnish the desired information. A general view seems to indicate that the path takes a direction from N.N.E. to S.S.W. across the tableland, curving eastward as it nears the south coast. The following are specimens:—

Area.	V_2.	Epoch of Maximum.	
Section XIII.	45°·1	Feb. 7	Aug. 9
XI.	23°·9	Feb. 18	Aug. 19
X.	313°·3	Mar. 26	Sept. 24

Area.	V_2.	Epoch of Maximum.	
Section XIV.	24°·5	Feb. 17	Aug. 18
VIII. E.	357°·5	Mar. 3	Sept. 2
VII. or VI. E....	332°·0	Mar. 16	Sept. 15
V. E.	292°·9	April 5	Oct. 5
IV. E.	263°·8	April 20	Oct. 19
IX. E.	356°·2	Mar. 4	Sept. 3
VIII. W.	323°·5	Mar. 21	Sept. 19
VI. W.	276°·8	April 13	Oct. 13
V. W.	307°·7	Mar. 29	Sept. 27
IV. W.	281°·0	April 11	Oct. 11
IV. E.	263°·8	April 20	Oct. 19

Section VI. W. is the one apparent exception to the orderly sequence of dates in this arrangement. Yet it is to be observed that the Zwartberg Pass is in this Section. Now the monthly averages for this station are obtained chiefly from casual observations of rainfall in occasional months, regular observations only having been taken recently. A reference to Table 25 proves that the Zwartberg numbers, because of their great relative magnitude, have considerably influenced the averages of Section VI. W. The Matjesfontein results, however, are not of the highest excellence.

No very orderly scheme seems to include the angular magnitudes in V_3. They scarcely invite discussion, since much accuracy cannot be claimed for them.

The amplitudes u_1 decrease in absolute magnitude, latitude for latitude, from the coast inland. For example—

	u_1.		u_1.		u_1.
Section XV....	2·494	Section XII. ...	1·815	Section X.	1·285
XIII..	2·335	XI.	1·536	VII. ...	·756
XIV...	1·702	VIII. E.	·988	VI. E...	·541
IX. E.	1·201	VIII. W.	·417	VI. W..	·151
IX. W.	·402	III.....	·614	II.....	1·395
III....	·614			I.	2·524

This result does not mean, as might at first sight appear, that the amplitudes decrease with distance from the sea, because they actually tend to increase from south to north. The following are examples:—

	u_1.		u_1.		u_1.
Section X. ...	1·285	IV. E....	·155	IV. W....	·147
XI....	1·536	V. E. ...	·169	V. W. ...	·191

	u_1.		u_1.		u_1.
Section XIV..	1·702	VI. E....	·541	VI. W....	·151
		VII. ...	·756	VIII. W.	·417
		VIII. E	·988	IX. W....	·402
		IX. E....	1·201		

Here u_1 is rather less in IX. W., than it is in VIII. W.—a result perhaps due to some affinity between these two Sections and Sections I., III. The amplitude in Section III. is considerably less than that of Section I.

Some of these results take a different aspect if we replace the absolute magnitudes of the first amplitude by the relative magnitudes. We then have—

	u'_1.		u'_1.		u'_1.
Section XV....	834	Section XII.	815	Section X.	537
XIII..	835	XI.	768	VII.	592
XIV...	875	VIII. E...	767	VI. E. ...	692
IX. E.	951	VIII. W.	561	VI. W....	135
IX.W.	824	III.	767	II.	738
III....	767			I.	749
X. ...	537	IV. E. ...	74	IV. W....	86
XI....	768	V. E.....	167	V. W. ...	210
XIV..	875	VI. E. ...	692	VI. W....	135
		VII.	592	VIII. W..	561
		VIII. E...	767	IX. W....	824
		IX. E. ...	951		

Here VI. W. is again obtrusive. Making due allowance for it, it seems that there is a slight tendency to an increase inland along the parallels, which, however, is quite overridden by the strong increase inland along the meridians.

If the amplitudes of the first harmonic term be arranged along the orbit, as was done for the epochs, it appears that the absolute values gradually decrease, with, however, some little irregularity. The relative values, on the other hand, first increase and then decrease:—

	u_1.	u'_1.
Section XV.	2·494	834
XII.	1·815	815
XIII.....	2·336	835
XIV.	1·702	875
IX. E.	1·201	951

	u_1.	u'_1.
Section IX. W.	·402	824
VIII. W. ...	·417	561
VI. W.	·151	135
V. W.	·191	210
IV. W.	·147	86

The following is the variation from east to west in the absolute amplitude of the second harmonic term :—

	u_2.		u_2.		u_2.
Section XV. ...	·112	Section XII.	·182	Section X.	·322
XIII. ...	·370	XI.	·404	VII. ...	·245
XIV. ...	·347	VIII. E...	·264	VI. E. .	·134
IX. E. .	·241	VIII. W..	·157	VI. W..	·218
IX. W..	·199	III.	·112	II. ...	·281
III. ...	·112			I.	·562

A remarkable feature about these amplitudes is that they tend to a maximum from the tableland side of the Drakensbergen southward to the sea. Thus the region of spring and autumn rains penetrates from the South Coast and Southern Karroo at least as far as the mountains of Basutoland. The reason why it cannot be easily detected in the monthly averages of Table 25 is that it is swallowed up by the great relative amplitude of the first term.

The corresponding values, in relative measure, are—

	u'_2.		u'_2.		u'_2.
Section XV. ...	38	Section XII.....	82	Section X.....	134
XIII....	132	XI.	207	VII. ...	192
XIV....	179	VIII. E.	206	VI. E.	171
IX. E.	191	VIII. W.	211	VI. W.	195
IX. W.	408	III.	140	II.....	149
III. ...	140			I.	167

We are better able now to understand how it comes about that while nearly the whole of Sections IV. and V. have maxima of rainfall in autumn and spring, the western halves of both have the primary maximum in April or May, whereas the eastern stations have either a primary maximum or a greatly increased (relatively) secondary maximum in September. At first sight we should expect that the maxima of these eastern stations would approximate to those of the neighbouring Sections VII., VIII. E., and XI., rather than that the western stations should do so. But the explanation,

as indicated above, is that the annual rain wave, becoming later and weaker as it journeys inland from the east coast, meets the south coast somewhere between Mossel Bay and Cape L'Agulhas in April, and reinforces the strongly marked semi-annual rain wave of the South Coast there, being scarcely felt at all further east.

It being fairly clear that the rains of Kimberley and Durban are included in the same system of summer rains, the extent of the relationship becomes an interesting question. Daily observations are published for the latter place, and therefore individual rains as well as monthly totals may be considered. Now it happens that there is not any real resemblance in the character of the showers of the two places. At Kimberley the heavier rain comes with a barometric depression; at Durban with a barometric crest. At Kimberley, speaking at large, the barometer rises as the heavy rain ceases; if there be more rain it is generally in small clearing showers. At Durban the barometer falls when the rain comes to an end. There were at Kimberley, in the five years 1897–1901, 72 heavy rains sufficiently isolated from other rain to admit of direct comparison with the pressures; at Durban there were 100 during the same period. By tabulating the barometric pressures of the days upon which the rain ended, for either place, together with three days before and two days after, we get the following comparative series of averages:—

	Durban.	Kimberley.
Third day before.....	30·075 inches	26·139 inches
Second ,, ...	30·061	26·131
First ,, ...	30·135	26·102
RAIN DAY	30·252	26·090
First day after.....	30·158	26·130
Second ,, ...	30·125	26·137

This is a result of considerable importance.

From a comparison of the monthly averages of Kimberley and Durban I have tried to determine whether a wet or a dry month at one place signifies a like or unlike state of things at the other. In Table 27 this has been done by tabulating in four columns:—

1. When the fall at both places is less than the mean.
2. When the fall at both places is greater than the mean.
3. When the fall at Durban is greater than the mean, but at Kimberley less.
4. When the fall at Durban is less than the mean, but at Kimberley greater.

The Table includes the twenty-six years 1877–1902—*i.e.*, 312

months. The two last columns show how many of these months had a fall less than the mean. It appears that there were 126 months in which both places together had a fall less than the mean; 53 in which the fall was greater than the mean at both; 63 in which the fall at Durban was greater, and at Kimberley less; 70 in which the fall at Durban was less, and at Kimberley greater. Is this anything more than chance? A perfectly chance distribution would give:—

When both stations together are less than the mean	119
When both together are greater	46
Durban greater and Kimberley less.....	63
Durban less and Kimberley greater.....	70

—the difference between the numbers in the last two lines evidently being a constant quantity. Thus there is an excess of 14 agreements greater than the 165 allowed for by the matured chances, which amounts to a deviation of both together in the same direction of about one month in the year. So that even if there be a relationship between these two stations it is not very decided.

Related more or less closely to the variation of rainfall is the cloudy state of the sky. This last element is stated in monthly averages in Table 28. Great accuracy must not be expected in these numbers, although they may possibly show the shape of the annual curves fairly well. It is a surprising fact that although the observation for the amount of cloud demands less skill than the reading of any instrument, it is done much more inaccurately. It is surprising sometimes how the percentage of cloud at a given station changes when the observer is changed; it is still more surprising how the observer himself sometimes changes. Kimberley observers have not on the whole made very comparable observations, as may be, *e.g.*, seen in the returns from Central Jones Street (G. J. Lee), and from the Meteorological Commission Station (C. Aburrow), for 1887.* That they may easily agree well enough is proved in the returns from Kenilworth, Kimberley (J. R. Sutton), and from Lennox Street (H. F. Harrison), for 1898.† Certainly the Kenilworth averages seem to be fairly consistent, as tested with the sunshine recorders. The following are the total percentages of sunshine *plus* cloud during daylight, year by year :—

1898	108 per cent.
1899	112
1900	111
1901	112
1902	110

* *Report of the Met. Com.*, 1887. † *Ibid.*, 1898.

The two earliest years had one observation of cloud in the morning and one in the afternoon; but the three later had two in the morning and two in the afternoon.* The Royal Observatory averages are also probably fairly good, since they agree on the whole with the Simonstown results. A change of method on the part of a single observer appears in the sudden drop in the estimated percentage of cloud at Graaff Reinet in 1892. For the nine years earlier than 1902 the average appeared as 39 per cent., varying from 35 per cent. to 44 per cent.; in the next seven it appeared as 16 per cent., varying from 12 per cent. to 21 per cent. But a new observer in 1900 immediately doubled this last low estimate. Defects being understood, we cannot always compare the cloudiness of one station with another, but only, sometimes, the annual variation at the same station.

From Table 28 I have selected a number of what seemed to be the best of the cloud averages, and determined the constants as far as the third harmonic term, putting in also the corresponding constants for rainfall, together with the rainfall constants for Adelaide and Alice Springs (South Australia), and Cordoba (Argentine). It is interesting to compare the South African numbers in this Table with those of Table 26, these being for stations, those for areas. The rainfall constants given here for Kimberley differ somewhat from those in the full formula computed above directly from Tables 1–12, for various reasons. The last are obtained from twenty-four nearly equal portions of a year. The values given in Table 29 (with the exception of Cordoba) are computed from the twelve months of various lengths reduced to thirty days. Thus the constants apply to the rate per month, rather than to aliquot parts of a year. The error introduced makes the times of the turning-points some four days too early in the first term, and seven days in the second. For comparative purposes only this is not of any great importance. In the third and later terms, however, the error is likely to be more serious. In the matter of the Cordoba numbers, the magnitudes given in "el Clima de Cordoba" are reckoned from January 1st. They are also determined from the average rainfall during each one-twelfth of a year. Before quoting them here they have been altered to count from the middle of January, so as to compare better with the others.

It appears from Table 29 that there is no very near approach to agreement between the epochs of cloud and rain for the different stations. At Durban, East London, and Kimberley the two elements

* At Torquay, for the year 1899, the total percentage of (sunshine *plus* cloud) during daylight is 104·4. A. Chandler, *Met. Rep. for* 1899.

tally fairly well. So do they also at Clanwilliam. At Aliwal North only in the annual term. At Simonstown the annual term of rainfall is a month earlier, and the semi-annual term a month later than the corresponding terms of cloud. Any correspondence at Port Elizabeth and Mossel Bay is only in the semi-annual terms. At the same time it seems not unlikely that the same annual cloud wave whose crest passes over Durban about the middle of December passes over Port Elizabeth and Mossel Bay a fortnight and five weeks later respectively, and a fortnight later still over Kimberley and Aliwal North. Nevertheless, it has lost its relative rank with respect to the second term by the time it reaches the south coast. It brings practically no rain, the annual wave of precipitation which started from the east coast with it not arriving until three months later.

Where do our rains originate? It has been stated pretty frequently and positively that they come from the south-east in summer and from the south-west in winter; that enormous quantities come from the South Indian Ocean in the summer, watering the greater part of the land south of the Zambesi; whereas the little that comes from the South Atlantic during the winter is all deposited within sight of Table Mountain.* One view connects them with the permanent anticyclones spreading across the ocean in these latitudes.† It is not clear, however, that such explanations represent all, or even more than a small portion, of the facts.

If these rains originate entirely in the south, it is indeed strange that practically all the cloud currents over Kimberley have a larger or smaller northerly component! Heavy thunder-clouds mostly advance from the west or north-west. Other rain clouds, and lighter thunderstorms, from somewhere between north-east and east. Scarcely any clouds come from the south-east, and very few from the south-west. The diurnal variation of the wind at Kimberley may be arrested, and the vane point for two or three days towards the south-east, and never a cloud obscure the sky. The variation may be arrested, and the vane point anywhere between east and north, and the sky be overcast and rain fall in abundance. And in almost every case the direction of the cloud movement is independent of the surface wind. One difficulty in settling such a question is paucity of observations: saving for one

* Maury claimed that the rain of the world came chiefly from the southern hemisphere. The atmosphere "is an engine. The South Seas . . . are the boiler for it, and the northern hemisphere is its condenser" (*Physical Geography of the Sea* (1859), p. 52).

† Buchan, "Rainfall of South Africa," p. 16.

station, and that not under the control of the Meteorological Commission, we know next to nothing of the wind system of any place in Cape Colony. The statements that connect general wind changes with precipitation on the central tableland are probably misleading because they ignore the undetermined diurnal variation of the vane. So far as the coast stations are concerned it is still an open question as to the manner in which the wind-directions are modified by the great bulk of the tableland.

In the light of these drawbacks the numbers given in Table 30 must be discounted according to taste. They show, to the limits of our knowledge, the frequency and average fall of rain corresponding to particular wind-directions, at Durban, for the eighteen years 1885–1902, and at Kimberley for the nine years 1894–1902 (but reduced to eighteen years for purposes of comparison). The argument for Durban is the quantity of rain exceeding half an inch in twenty-four years for any day, and the wind direction at 9 a.m. entered to the same day. The Durban rain-day ends at 3 p.m. The argument for Kimberley is the quantity of rain for the twenty-four hours ending 8 p.m. on any day, and the wind-direction at 8 a.m. on the same day. Thus the wind is observed at the middle of the rain-day.

It appears from the Table that a south-west wind brings more rain to Durban than any other direction, the next most important direction being the south. A considerable quantity, also, falls in calms. Upon the whole, if we neglect calms, it may be affirmed that the rain winds of Durban tend to blow nearly parallel with the coast, the resultant direction being almost S.W. by S. The third most important direction is west. It is remarkable that so much should come from this point, which is directly from the considerable mountains of Basutoland.

At Kimberley the scheme is very simple. The resultant direction is appreciably from N. by E., practically nothing coming from any point having a south-westerly component.*

Thus two places not far from the same parallel of latitude, and in the same system of summer rainfall, have their chief rain-bearing winds from entirely opposite points of the compass. This result, however, is really what might have been expected from the opposite relationship to the variations of atmospheric pressure manifested by the rains of the two places. It seems to follow that the direction of the wind is only important in so far as it relates to the baric

* If we observe the wind at 8 p.m. on the day before, *i.e.*, at the beginning of the rain-day, the resultant direction becomes nearly E. by N. This alteration is due to the influence of the diurnal oscillation of the vane.

gradients.* Now Prof. Morrison has pointed out that barometric depressions in most cases start from the south coast and travel in some northerly direction.

We may then summarise all that is known of the predominant conditions determining South African rainfall, outside the Cape Peninsula and West Coast, in the following paragraphs :—

The rain decreases on the whole with distance from the coast.

It comes with a high pressure at Durban, and a low pressure at Kimberley.

It comes chiefly with south-westerly winds at Durban, and with north-easterly winds at Kimberley.

The principal barometric disturbances come from the south.

The clouds over the tableland come from some northerly point.

We may be certain that the winds blowing on-shore along the west coast carry comparatively little moisture, not so much because of the short superoceanic path they are said to traverse (owing to the influence of the permanent anticyclone near by), as because of the coldness of the water.† An interesting parallel is found on the coast of California. It is referred to here because of the very apropos explanation it has elicited: "On the coast of Southern California the sea-breeze blows throughout the greater part of the year. It is weak in winter and strong in summer. During the latter season it is a dry wind even on the coast. . . . The cause is undoubtedly to be found in the fact that the ocean near the coast is very cool, while, on the other hand, the land is very much warmed. The air that comes off the ocean must therefore seem relatively dry over the land."‡ The same argument holds with us, *mutatis mutandis*. Port Nolloth, on the west coast, with only 2·5 inches of rain per annum, is a far more humid place, because of its lower temperature, than Port St. John's, on the east coast, with a rainfall ten or twelve times greater. But Umtata, thirty-five miles inland from the east

* It is interesting to compare these conditions with corresponding phenomena on the coast of Syria: "The barometer is *usually* on the rise during a rain. A south-west wind concurs with a rise from a low barometer." Moreover, "as long as the wind blows steadily from the west or south-west there is usually no rain. But when it blows for a day or two from the east, south, or south-south-west, and then veers suddenly to the west or south-west, rain is very apt to fall. (G. E. Post, "Notes on the Meteorology of Syria and Palestine," *Trans. Vic. Inst.*, vol. xx., pp. 284, 280.) At Manila the rain accompanies the depression, tending to its greatest rate of fall after the passage of the minimum pressure. (See Loomis, "Contributions to Meteorology." *Memoirs N.A.S.*, vol. iii., 1886.

† "The temperature of the sea near Cape Town is sometimes 20° lower than in the corresponding latitude on the eastern side of the continent" (Scott, *Elementary Meteorology*, p. 299, 6th Edition).

‡ Hann's "Handbook of Climatology" (Ward's Edition), p. 156.

coast, is almost as humid as the coast, whereas O'okiep, fifty miles inland from the west coast, is exceedingly dry, and become so because the high temperature of the land as compared with the sea has lessened the relative humidity. This principle was known at end of the eighteenth century at least. Dalton has the following characteristically sagacious remarks upon the rainfall conditions of the north-west of England: "The reason that a S.W. wind in these parts brings rain seems to be that, coming from the torrid zone, it is charged with vapour, and the heat escaping as it proceeds northward, a precipitation of the vapour ensues; but a N.E. wind, blowing from a cold into a warmer country, has its capacity for vapour increased, and therefore we generally find it promote evaporation." *

The interpretation of these facts seems to be that our rain originates on the equator, being carried hither in the upper atmospheric currents flowing from the west and north. The rain begins on the east coast when this moist upper stratum meets the lower bodies of air damp with moisture from the Indian Ocean. Then it gradually works back from the east coast as the eastern air becomes heavier with vapour.†

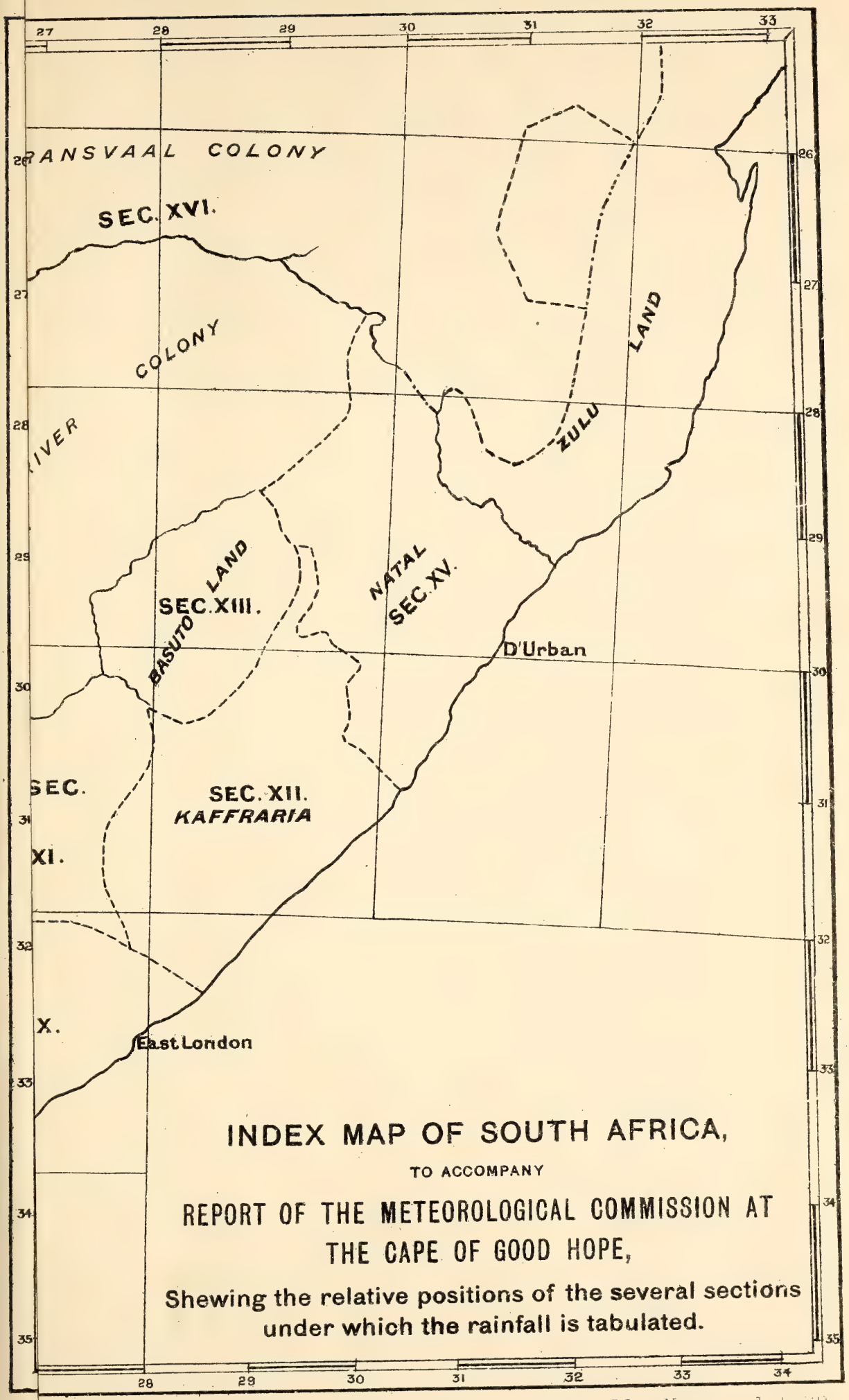
Now the upper current, though it may be nearly saturated at its low temperature aloft, does not increase its absolute humidity by commingling with the air of the west coast, and therefore can flow across the slopes bordering the tableland without being induced to condense its moisture.

The copious rainfall of the district extending from Ceres to Table Mountain is perhaps largely promoted by its proximity to the region where the warm Agulhas and cold Benguela currents meet. Wojerkof mentions this cold current in connection with the aridity of the West Coast:—"An der Küste rührt diess zum Theil von der kalten Meeresströmung her, welche in der Nähe fliesst und von welcher aus kalte S.W.—und Süd Winde nach der Küste wehen. Die Passatwinde von der Ostküste kommen über das hohe Binnenland her schon in einem sehr trockenen Zustand an" ("Die Atmosphärische Circulation, &c.," in Erg. No. 38. Geo. Mitt. 1874).

* Dalton, "Meteorological Observations and Essays," 2nd ed., 1834, p. 132.

† The month of greatest average rainfall over Natal is December (see Table 25), whereas the quantity of moisture in the air of Durban is greatest in February. At Durban itself, October, with a mean moisture of 5·8 grains per cubic foot, has as great a daily rainfall as February, with a mean moisture of 7·5 grains.

Plate I.



INDEX MAP OF SOUTH AFRICA,

TO ACCOMPANY

REPORT OF THE METEOROLOGICAL COMMISSION AT THE CAPE OF GOOD HOPE,

Shewing the relative positions of the several sections under which the rainfall is tabulated.

West, Newman photo-lith.

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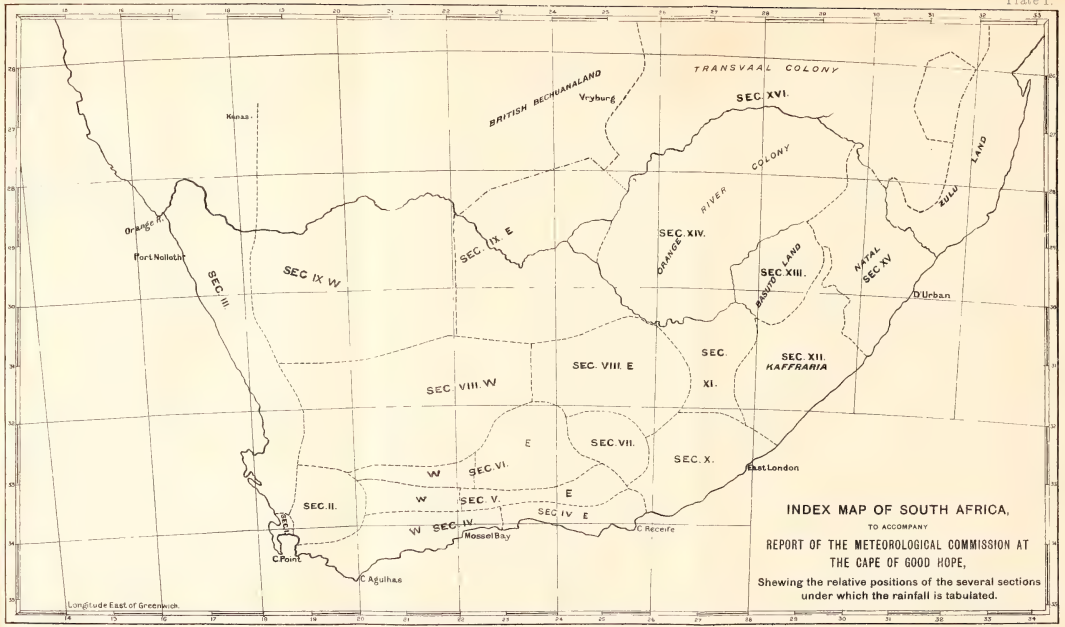

TRANSVAAL COLONY
BRITISH BECHUANALAND
Vryburg
Kenas
SEC. XVI.
COLONY
RIVER
ORANGE
ZULU
LAND
Orange R.
Port Nolloth
SEC. III
SEC. IX W
SEC. IX E
SEC. XIV.
ORANGE
BASUTO LAND
SEC. XIII.
NATAL
SEC. XV
D'Urban
SEC. VIII. W
SEC. VIII. E
SEC.
XI.
SEC. XII.
KAFFRARIA
E
SEC. VII.
W
SEC. VI.
SEC. X.
East London
W
SEC. V.
E
SEC. II.
SEC. I.
W SEC. IV.
SEC. IV E
C Receife
Mossel Bay
C Point
C Agulhas
Longitude East of Greenwich.
INDEX MAP OF SOUTH AFRICA,
TO ACCOMPANY
REPORT OF THE METEOROLOGICAL COMMISSION AT THE CAPE OF GOOD HOPE,
Shewing the relative positions of the several sections under which the rainfall is tabulated.
0 50 100 200 300 400 500 Eng. Miles
Scale of British Miles.

13	4	293		3	--	6	--	--	1	3	2	4	67	

Table 1. January Rainfall at Kimberley

Day	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	Total in 26 years	
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	Days	Inches
Jan 2					190	030									070			150	002	034			040		055		8	.571
3						660											217	170				130	030				5	1.407
4					260						090	020	037		135				290	287	073	350	095		525		11	2.162
5			.030					120		038	141	006	1.272						227		610			285			9	2.759
6				020		140	070						019				003					460		005			7	1.217
7			.080	230				210													1.155						4	1.675
8			.430	180				060	170								332						.190			015	7	1.377
9		070	1.060	070						081	360	1.148		489			340					790	050	580			11	5.038
10		050				190					.110		010										185	420			6	.965
11				360									002					010				220					4	.592
12				400	150										102	004	048	003	060			1.980				100	9	2.847
13		190		470	100									054	.110		400		050	101	.675	.570				005	11	3.125
14				430	100			030						114			096			070							6	.840
15		040		1.150						087				031		025	190			315		070		005		.065	10	1.978
16				020						028	229	.004			025	210			100	055		985		080		.120	11	1.856
17		130	110	010	030				010	358									055			.440	130	025		1.175	11	2.473
18			500					180		656								480		.097		345	120				7	2.378
19			090					040					150		220	077		170			085	190	950				9	2.172
20					060							408	551			440			086		187		015				7	1.747
21	070				1.145			.050			154	425			.257	020	2.810	557			043			.140			11	5.671
22					880			900		103	104	056	036		165		275	.003								335	10	2.887
23			020		030			2.150						027				1.025	215		130	1.185				005	9	4.787
24	220							2.000						056	1.210			673			113	450					7	4.722
25	270	020					590	120				025	020	042	082					127	036	195		010	030	2.230	14	3.797
26	100				400	010	1.420	540						035	590		116					.030	115	070			11	3.426
27				130			580				067		073	076								040	310		005		8	1.291
28					1.810															024			035		.525		4	2.394
29			120					030		081						177				.047			.230		040		7	.725
30				100	490		170	020			163						497	570						075			8	2.085
31				160	330				040			036		012	420			1.225					135				8	2.258
32					725	065					.008			.482	122												5	1.402
Month	.660	500	2.440	4.130	6.700	1.595	2.830	6.450	220	1.452	1.426	2.158	2.170	1.418	3.508	953	5.324	5.436	1.095	1.157	3.107	8.430	2.630	1.695	1.150	4.050		72.714
Days	4	6	9	14	15	6	5	14	3	8	10	9	10	11	13	7	12	12	9	10	10	17	15	11	6	9	255	

Table 2. February Rainfall at Kimberley

Day	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	Total in 26 years	
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	Days	Inches
Feb 2	440				.310	010									825	413			016	117	.227		050			010	10	2.418
3					1.020						727	199			020			240	040	.360	430	015					9	3.051
4			020	010		010					238		693		175	040	360		.040	017		.020					11	1.623
5						045	070				002			1.223		066	002	155		356				.010			9	1.929
6			020							025	006	599		1.301	134	050	073	267	340	004					090	.005	13	2.914
7			170		.660				300				030	206			335	007	250						230	060	10	2.248
8												217		1.223	337		100								195		5	2.072
9						010		060				044	007												060		5	.181
10						015		090				381						007	.020		055						6	.568
11		340								093	1.080		387		012			.170	467			080				040	9	2.669
12		.930			020	045							024									.090	030	080		190	8	1.409
13	030					185		270		137				487	690							360			115	305	9	2.579
14				250		060				024		088			.164			1.410						045	565		8	2.606
15			140															366	350					080	090		5	1.026
16			170						005	210	125		176					1.413	003								7	2.102
17		880							.300		229		020					140					085		015		7	1.669
18				050							.125			641	066	256											5	1.038
19	020		020	010		290				111		1.250				230			235			030		265	1.465		11	3.926
20	170	110				015	610		430	010		036			087				184			170				.260	11	2.082
21	850	340	.020	230				770	980		163	210	283						130	013						085	12	4.274
22		140			020				020			205	021					060				210				435	8	1.111
23	400			050		310	030														013	140		470		090	8	1.503
24	070				070	495							008								225	.150		500			7	1.518
25	1.020	190	020	250	.140			120		007			098	035			415					470	110	.610		270	14	3.755
26	520			070	1.590		1.560	520					537	912	007		164					020	.205	225	140		13	6.470
27				050	2.140	035				921		220	024		020							040	1.735		030		10	5.215
28	360		2.200	040	060	215					307	004		.298		082	135	1.320		176		420	015		180	.215	16	6.027
29	220	070			075						046	.250		.022	830	040	.047		090		020		165		065	.270	14	2.310
30				190								347				165											3	.702
Month	4.100	3.000	2.780	1.200	6.105	1.740	2.270	1.830	2.035	1.538	3.148	4.050	2.308	6.348	3.367	1.342	1.631	5.555	2.165	1.043	.970	2.215	2.395	2.285	3.240	2.335		70.995
Days	11	8	9	11	11	14	4	6	6	9	11	14	13	10	13	9	9	12	13	7	6	14	8	9	13	13	263	

Table 3. March Rainfall at Kimberley

Day	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	Total in 26 years	
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	Days	Inches
Mar 2	.190		020	010				720	630		.018	1.098			.135				135					375		.170	11	3.491
3	030							170		003	452	003					192						030	020			8	.900
4		280	850		2.265	120			020	1.001		666					435			.415				.085	.135		11	6.272
5		280					550		170	1.294	007	086					046			105			605	1.355			10	4.498
6	.780		300					300		208	253	407	004					.435				025	080	105			11	2.897
7	.150		700			.755	050	180		015		215			575	066											9	2.706
8			.030			260		1.560		031		028					247	.020					020		215		9	2.411
9					1.320	020				166			145	.071			.030		017				145		170		9	2.084
10	030			090	1.200					021		374	023	107	030	146								090	095		11	2.206
11				.140	1.710		300						390		032	087		.455			.070		010		005		10	3.199
12		010			130													550		003	1.860		005		1.350	005	8	3.913
13		030			290	1.840	070						1.057		065	.095	078	027		040	.366	015	010	095	095	555	16	4.728
14	010				020	015	.330				087		.131	473	110			015				050	.070	.205		350	13	1.866
15			170											1.018	405	.108		036	.013	033		400	295			010	10	2.488
16					070				.930					034		.220			.643	1.053			485		035	355	9	3.825
17		050	300		1.210						.008				.117		.013		020	495	.786				715	025	11	3.739
18			1.070	090							.788				010	.187			020	033	045			025			9	2.268
19		.030	400	020	110			360		754	015				070	836	017				027	010		015			13	2.664
20						020	090	080				.003		027		274		010	010	013	2.375	405	300	.655			13	4.262
21						460	210	560		420		063	208	045	025	470		024		002		030	465		2.300		14	5.582
22		060					070						002							.157		025			1.250		6	1.564
23															015		010	810		070		060	350				6	1.315
24									030	.003		112			495				.197			035	015	1.305			8	2.192
25				.030	.020						045	1.281				.616			150	110				.380	510		9	3.162
26				100			020	480			073	.284				495		070	213								8	1.735
27			030	.030	.010							007			060	620	117	095	085					.015			10	1.069
28			010		055						349				1.485	355		130		047							7	2.431
29			460		020										1.620	002			.220	.260		.015					7	2.597
30															.745		.036			595		040			560		5	1.996
31			110		030										040			605				170				005	6	.960
32			170					.100					.007					110				025				020	6	.432
Month	1.190	740	4.620	510	8.460	3.490	1.690	4.810	1.780	3.916	2.095	4.617	1.967	1.775	6.034	4.597	1.221	3.392	1.723	3.431	5.529	1.305	2.885	4.725	7.455	1.495		85.482
Days	6	7	14	8	15	8	9	10	5	11	11	14	9	7	18	15	11	15	12	16	7	14	15	14	13	9	293	

Table 4. April Rainfall at Kimberley

Day	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	Total in 26 years	
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	Days	Inches
Ap. 2											133	004							.395			.080			600	.345	6	1.557
3						065					010								330			025			.010	320	6	.760
4										175									358	030						465	4	1.028
5						020						017		042		095				023			025				6	.222
6			060	010	450							991			566				255					.380	.295		8	3.007
7						880			090			118												410	035		5	1.533
8				030						147	142			581									010			195	6	1.105
9		.290					130			136	208			1.372					194				520			050	8	2.900
10		010										203	564	.377						233					065		6	1.452
11		.020						040									465			766			840				5	2.131
12		090						520		.086			008				.182			495		140	015	165			9	1.701
13								120									284						280	005		160	5	.849
14							370			002	007				135											315	5	.829
15						060					085				160	120								400			5	.825
16					040		040		630				245		137		260						860	510	650		9	3.172
17									110	.003		093			210			030	125					090		065	8	.726
18											.325				210		015	108	510	086	265			010			8	1.529
19					250						115	365			650				485	516	143		055	055			9	2.634
20					.730						002	056		674	185				720	065					025		8	2.457
21				150	010	040	120			144			051		035				090	347					110		10	.997
22							100			113			648								255					010	5	1.126
23							010			005							140	470			013		060				6	.698
24							010						004	029								035	050				5	.128
25							150						275	182		375		460				165	995				7	2.602
26	050									078			006								285		135				5	.554
27								040	010	017	007		002	007	072								010		005		9	.170
28										016	106	055	084		565												5	1.126
29										034		017								050					200		4	.301
30					060						251									397							3	.708
31											028									093		075					3	.196
Month	.050	.410	.060	.190	1.540	1.065	.830	.720	.840	.986	1.419	1.919	1.887	3.264	3.225	.590	1.346	1.068	3.462	3.101	.961	.520	3.855	2.025	1.795	1.925		39.023
	1	4	1	3	6	5	8	4	4	13	13	10	10	8	11	3	6	4	10	12	5	6	13	9	10	9	188	

Table 5. May Rainfall at Kimberley

Day	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	Total in 26 years	
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	Days	Inches
May 2							050				1.070	479					002	016				.120					6	1.737
3												.222						456	028			045	670				5	1.421
4												.646						.270	.627				080				4	1.623
5																			258	337			005				3	.600
6	010						220						173	529		015											5	.947
7			.240	.030										208									065				4	.543
8			170			100								121									510				4	.901
9			.030							016										063		005	010				5	.124
10																				050							1	.050
11																		040		1.546							2	1.586
12			.060			040		040																		005	4	.145
13															170												1	.170
14	200				.145																						2	.345
15									450				036								187						3	.673
16				200	380			140	160			616			025							.570					7	2.091
17		650			010						003				002			090				040					6	.795
18					1.050						473							010				240					4	1.773
19		060			410						310										026	105				110	6	1.021
20						1.010										002											2	1.012
21						050		020								070											3	.140
22												004				052											2	.056
23	.530		030																075					010			4	.645
24	070							020							100			286	012	020		020					7	.528
25	120							270										045				025		060			5	.520
26								330				002															2	.332
27							020	030				003			015						002	090					6	.160
28							040																				1	.040
29																						020					1	.020
30											012																1	.012
31											042								.235								2	.277
32					020										036												2	.056
Month	930	710	530	230	2.015	1.200	330	850	610	016	1.910	1.972	209	758	.348	.139	002	1.213	1.235	2.016	.215	1.280	1.340	070	--	115		20.243
Days	5	2	5	2	6	4	4	7	2	1	6	7	2	3	6	4	1	8	6	5	3	11	6	2	--	2	110	

Table 6. June Rainfall at Kimberley

Day	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	Total in 26 years	
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	Days	Inches
June 2								160																	015		2	.175
3			.030									095					027										3	.152
4																002				.150							2	.152
5			.350									.003															2	.353
6			450																	.030							2	.480
7			080		010																			025			3	.115
8														.023	110												2	.133
9					130									048		233											3	.411
10														003		626										315	3	.944
11														515	860	134				040						.275	5	1.824
12								140												125						080	3	.345
13								060						021													2	.081
14																											--	--
15									080																		1	.080
16									010											.104							2	.114
17				040																002				590			3	.632
18			020	010				120																070			4	.220
19			030															003									2	.033
20			.330																								1	.330
21																											--	--
22												004													085		2	.089
23																											--	--
24												014															1	.014
25															140											290	2	.430
26														.066	010												2	.076
27										083	562			021	315								360				5	1.341
28															068			040									2	.108
29																	040	013									2	.053
30						030											738										2	.768
31						130					602			477			.065										4	1.275
Month	--	--	1.290	050	.140	.160	--	480	090	083	1.165	116	--	1.174	1.303	.995	.870	056	--	451	--	--	.360	.685	100	.960		10.828
Days	--	--	7	2	2	2	--	4	2	1	2	4	--	8	6	4	4	3	--	6	--	--	1	3	2	4	67	

4	8	71		11	16	7	6	11	13	10	8	222		

Table 7. July Rainfall at Kimberley

	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	Table — 26 years Days Inches
July 2																											
3							020																				
4																											
5																											
6			330																								
7			040																								
8																											
9	090																										
10	050																										
11	200																										
12	210																										
13	130																										
14										196																	
15										197																	
16																											
17			050													032											
18		630														120	083										
19			020																								
20																											
21			030														030										
22																											
23			020																								
24						470																					
25						490											018										
26																											
27						060																					
28																											
29																											
30																											
31			120			130																					
32						080																					
Month						1110																					
Days						5																					

Table 8. August Rainfall at Kimberley

	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	Table — 26 years Days Inches
Aug 2							430																				
3																											
4										004	032																
5											003																
6																											
7																											
8																											
9																											
10																											
11																											
12																											
13																											
14																											
15																											
16																											
17																											
18																											
19																											
20																											
21																											
22																											
23																											
24																											
25																											
26																											
27																											
28																											
29																											
30																											
31																											
Month																											
Days																											

Table 9. September Rainfall at Kimberley

	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	Table — 26 years Days Inches
Sept 2																											
3																											
4																											
5																											
6																											
7																											
8																											
9																											
10																											
11																											
12																											
13																											
14																											
15																											
16																											
17																											
18																											
19																											
20																											
21																											
22																											
23																											
24																											
25																											
26																											
27																											
28																											
29																											
30																											
Month																											
Days																											

Table 10. October Rainfall at Kimberley

	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	Table — 26 years Days Inches
Oct 2	200																										
3	030																										
4																											
5																											
6																											
7																											
8																											
9																											
10																											
11																											
12																											
13																											
14																											
15																											
16																											
17																											
18																											
19																											
20																											
21																											
22																											
23																											
24																											
25																											
26																											
27																											
28																											
29																											
30																											
31																											
Month																											
Days																											

Table 11. November Rainfall at Kimberley

	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	Table — 26 years Days Inches
Nov 2																											
3																											
4																											
5																											
6																											
7																											
8																											
9																											
10																											
11																											
12																											
13																											
14																											
15																											
16																											
17																											
18																											
19																											
20																											
21																											
22																											
23																											
24																											
25																											
26																											
27																											
28																											
29																											
30																											
Month																											
Days																											

Table 12. December Rainfall at Kimberley

	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900	1901	1902	Table — 26 years Days Inches
Dec 2	040																										
3	180																										
4																											
5																											
6																											
7																											
8																											
9																											
10																											
11																											
12																											
13																											
14																											
15																											
16																											
17																											
18																											
19																											
20																											
21																											
22																											
23																											
24																											
25																											
26																											
27																											
28																											
29																											
30																											
31																											
Month																											
Days																											

4,063 4,646 4,903 5,306

Table 13 Rainfall at Kimberley

	F. H. Matthews														G. J. Lee		Meteorological Commission		J. R. Sutton (Kenilworth)		Port Elizabeth		Durban	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year	Year
	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	days	inches	days	inches	days	inches	days	inches	days	inches	days
1877	66	388	141	05	93	..	66	35	87	124	135	218	1358	54									3567	
8	50	293	81	41	71	..	63	110	·	16	115	94	934	45									2824	
9	244	278	445	23	53	129	61	30	595		27	53	1918	75									4446	
1880	532	134	60	30	23	02			·	210	150	402	1543	62			1455	68			2480	54	4768	
1	595	605	810	140	173	13	·	84	-	43	503	64	3030	68			3391	76			2252	70	3723	
2	160	130	130	108	127	03	81	75	126	47	80	160	1477	52			1545	94			1727	74	3621	
3	264	179	153	56	23	-	72	12	13	88	259	02	1121	44			1363	42			2317	79	4458	
4	645	183	471	82	85	37	..	·	31	73	84	152	1843	66	2047	73	2052	64			1971	84	4453	
5	20	2.05	152	90	57	08	·	80	153	05	75	68	963	61	979	74	1138	57			1714	71	3448	117
6	134	136	370	104	·02	08	34	19	08	51	08	570	1444	80	1524	83	1665	60			2256	76	3179	123
7	149	293	181	137	199	56	137	73	07	99	95	448	1874	85	1883	98	2304	70			1622	72	3187	144
8	204	336	458	1.83	2.01	·12	..	29	177	73	01	60	1734	74	1862	86	1938	58			2794	96	3814	145
9	262	201	149	195	23		-	16	22	445	231	165	1749	59	1884	80	1924	53			2502	79	2928	113
1890	91	689	166	301	71	75	96	08	·	144	329	341	2311	67	2355	81	2522	66			1528	69	3290	135
1	329	288	651	262	29	119	14	102	46	148	549	593	3130	95	3225	105	3423	90			2482	85	4545	128
2	94	115	484	63	13	106	·	05	184	140	67	17	1288	62	1295	70	1366	50			1916	69	3837	125
3	570	155	136	141	01	83	19	58	-	24	220	218	1625	80	1537	80	1595	58			2246	91	7127	152
4	758	581	251	118	118	05	·	29	41	129	240	233	2503	72	2493	80	2520	68	2451	84	1609	65	3727	152
5	131	199	197	361	114	-	24	·	02	05	250	315	1598	67	1547	75	1590	58	1560	81	1688	67	5150	181
6	123	85	327	308	220	50		37	·	04	87	745	1986	80	1977	87	2058	63	2107	90	1709	65	3965	158
7	295	113	524	90	19	-	·	08	·	130	..	79	1258	40	1341	42	1392	39	885	49	2623	67	2439	172
8	898	230	167	83	126	-	·	07	08	112	221	75	1927	64			1847	70	1829	83	2228	74	4248	165
9	255	148	3.00	359	110	42	111	23	16	169	1.41	85	1759	78			1911	77	1938	100	1041	49	2875	182
1900	137	188	429	228	04	71	173	10	·	177	41	236	1694	69			1761	66	1878	81	1742	69	2724	160
1	61	327	850	237	·	09		06	189	99	18	608	2404	62			2427	68	2223	79	2038	93	5554	184
2	420	142	168	160	17	71	07	07	330	186	216	103	1827	63					2224	75			4118	160

Table 14 Total Rainfall at Kimberley for the 26 years 1877–1902, in equal intervals of 15¼ days each

		inches
Jan	(1)	28.759
	(2)	43 254
Feb	(1)	29 745
	(2)	48.250
Mar	(1)	48 121
	(2)	34 619
Apr	(1)	22 629
	(2)	17 352
May	(1)	11 958
	(2)	6 636
Jun	(1)	5 660
	(2)	6 336
Jul	(1)	4 150
	(2)	3 488
Aug	(1)	2 590
	(2)	6 647
Sep	(1)	7 914
	(2)	16 331
Oct	(1)	9 323
	(2)	21 020
Nov	(1)	27 558
	(2)	18 896
Dec	(1)	32 614
	(2)	29 174
		483 024

Table 15. Epitome of Rainfall at Kimberley

	No. of Rainy Days in 26 years	Average No. of Rainy Days	Total Rainfall in 26 years	Average Rainfall	Average Rainfall per day	Average Rainfall per Rainy Day	Greatest Rainfall in one Day	Greatest Rainfall in one Month	Chance of a Rainy Day per 100
			inches	inches	inch	inch	inches	inches	
Jan	255	10	72.714	2.797	·090	285	2.810	6 700	31
Feb	263	10	70 995	2 731	097	270	2 200	6 348	36
Mar	293	11	85 452	3 287	106	292	2 375	8 460	36
Apr	188	7	39 023	1 501	050	208	1 372	3 855	24
May	110	4	20 243	779	025	184	1 546	2 016	14
Jun	67	3	10 528	405	014	157	738	1 303	9
Jul	48	2	8.954	344	011	187	1 015	1 605	6
Aug	63	2	9 477	364	012	150	970	1 672	8
Sep	71	3	23 750	913	030	335	4 520	5 950	9
Oct	145	6	30 838	1 186	038	213	3 442	6 097	18
Nov	180	7	44 748	1 721	056	249	4 250	7 030	23
Dec	222	9	63 494	2 442	079	286	3 165	6 969	28
Year	1905	74	480 216	18 470	050	250	4 520	8 460	20

Table 16A Number of Daily Rainfalls at Kimberley of given quantity, from 1877 to 1902.

Less than 100 in	100 in to 499 in	500 in to 999 in	1 inch to 1.999 in	2 inches and over
109	103	25	14	4
115	110	22	14	2
142	98	29	21	3
87	78	22	1	..
63	34	9	4	..
39	21	7	..	-
22	21	4	1	-
39	17	7	..	..
33	28	3	5	2
72	51	21	..	1
91	68	12	6	3
97	86	23	13	3
909	715	184	79	18

Table 16 B. Number of Monthly Rainfalls at Kimberley of given quantity, from 1877 to 1902

Nil	0 in to 999 in	1 in to 1.999 in	2 in to 2.999 in	3 in to 3.999 in	4 inches and over	No. of Falls in which the fall was less than the Mean
	4	8	5	2	7	16
-	1	7	9	4	5	16
-	2	9	2	4	9	13
-	11	9	1	5		15
1	16	7	2	..	-	15
7	15	4	..	..	..	16
9	15	2	·	..	-	17
4	19	3	-		·	18
8	11	4	1	..	2	19
1	10	14	-		1	14
1	10	7	4	2	2	15
1	7	6	2	5	5	15
32	121	80	26	22	31	189

Table 17 The Diurnal Variation of Rainfall at Kenilworth, Kimberley. 1897 — 1902

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	N	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	M	Total
	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches	inches
Jan	772	474	1021	243	1315	705	211	226	222	051	249	642	611	815	569	2182	1964	572	1263	1145	647	689	797	1181	18.566
Feb	358	1100	1409	·168	188	189	345	230	326	037	101	184	198	418	627	549	609	1058	670	671	803	893	346	387	11864
Mar	1076	612	679	460	421	549	684	524	470	496	276	616	720	467	1384	1185	643	1064	656	1887	908	558	1167	913	18625
Apr	400	337	348	592	139	139	172	195	077	120	475	051	027	911	524	594	1296	1006	·345	686	545	337	358	508	10182
May	029	378	187	203	217	278	170	083	108	006	090	160	127	010	030	003	025	066	081	051	033	·111	091	041	2588
Jun	025	032	101	219	007	·003	052	069	009	065	050	100	213	051	002	107	·037	099	053	105	279	223	069	025	1995
Jul	012	112	074	164	106	173	083	143	122	·104	·044	008	011	080	197	735	036	·019	127	071	062	047	017	028	2575
Aug	026	112	102	034	013	010	002	004	008	·004	·007	..	·	..	..	043	069	003	007	·005	·003	070	117	102	741
Sep	328	303	023	133	175	409	239	057	003	003	047	005	..	174	055	025	1333	2185	176	398	807	453	580	482	8393
Oct	258	·122	232	128	025	005	001	049	104	306	469	270	163	411	·675	916	817	730	315	230	219	·584	104	191	7324
Nov	244	196	058	·043	019	074	052	058	233	030	033	081	235	552	·455	671	·637	517	322	205	088	005	015	1301	6124
Dec	385	370	636	299	249	073	093	264	156	616	007	256	667	618	1.129	937	902	622	1383	1189	610	130	537	797	12925
6 years	3913	4148	4870	2686	2.874	2607	2104	1902	1838	1838	1848	2373	2.982	4507	5847	7947	8378	7941	5398	6643	5.004	4100	4198	5956	101.902
annual average inches	652	691	812	·448	479	434	·351	317	306	306	308	396	497	751	975	1325	1396	1323	900	1.107	834	683	·700	·993	16.984
	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours
Jan	10	12	13	8	10	12	9	8	6	5	8	7	12	17	22	24	20	15	21	20	16	14	18	14	321
Feb	13	12	11	7	10	5	6	5	5	3	4	3	5	8	13	11	11	17	20	14	19	12	12	11	237
Mar	10	13	11	9	11	9	11	11	11	12	10	12	14	11	15	15	16	14	18	20	19	19	18	14	323
Apr	10	11	6	10	9	6	3	5	8	7	8	3	8	14	18	18	16	11	11	18	16	12	13	12	253
May	7	6	5	6	7	9	6	4	3	1	2	2	3	2	2	1	3	3	3	4	1	6	4	6	96
Jun	1	2	2	2	1	1	1	1	1	3	1	2	3	3	1	3	2	2	4	4	6	7	4	2	59
Jul	3	3	5	3	5	7	5	3	2	3	2	2	3	4	4	5	4	4	5	4	4	3	4	4	91
Aug	3	4	3	4	3	1	1	1	1	1	1	-	..	..	..	2	2	1	1	1	1	3	3	3	40
Sep	7	4	4	3	2	2	3	1	1	1	2	1	..	2	1	2	6	8	6	6	8	8	9	8	95
Oct	2	4	5	5	4	2	1	4	6	4	3	7	7	6	9	13	13	12	7	12	7	6	9	10	158
Nov	4	4	4	4	3	3	3	4	3	3	3	3	3	5	7	11	11	9	9	9	6	2	3	4	120
Dec	4	7	7	5	6	3	4	6	4	3	2	6	7	12	19	20	15	14	17	15	17	7	10	8	218
6 years	74	82	76	66	71	60	53	53	51	46	46	48	65	84	111	125	119	110	122	127	120	99	107	96	2011
Annual average Hours	12.3	13.7	12.7	11.0	11.8	10.0	8.8	8.8	8.5	7.7	7.7	8.0	10.8	14.0	18.5	20.8	19.8	18.3	20.3	21.2	20.0	16.5	17.8	16.0	335.2
	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch	inch
Average fall per Rainy Hour	053	051	064	041	040	043	·040	036	·036	040	040	049	046	·034	053	064	·070	072	045	052	·042	·041	039	·062	·051

Table 19. The Diurnal Variation of Thunder + Lightning at Kenilworth Kimberley, 1897 — 1902

1. Thunder and Thunderstorms

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	N	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	M	Total
	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours
Jan	1	½	½	1½	1	1¼	2	-	1¼	..	¼	1	9¼	12¼	20	19	12¼	14¼	17¼	11¼	6	4	8	3¼	149½
Feb	4	2	1¼	..	..	-	1	-	1	1	1	1	3¼	5½	5¼	9½	11	10¼	11	12½	7	2¾	4¼	5¼	161
Mar	3	2	1¼	1	1	1	1¼	1¼	1½	½	1¼	4¼	8	12¼	13¼	15	10½	14¼	17¼	9	8½	8¼	11½	10½	157
Apr	1	..	..	1	·	..	..	1	..	·	¼	..	2¼	7½	9¼	13¼	9	10¼	9¼	8	5¼	5	5	1	90¼
May	--	--	--	·	..	--	..	..	-	-	1	1	1	1	1	½	1	¼	½	¼	2½	1	1	·	1½
Jun	½	1	--	--	-	--	..	..	½	1	1	1	1	..	--	-	-	¼	1	1	2¼	1	1	1	5½
Jul	·	--	--	1	1	1	1	-	..	--	1	2	1	2	--	-	½	1½	2	1¼	1	¼	..	1	8½
Aug	1	2	-	..	..	-	-	-	..	-	..	..	·	..	-	1¼	2¼	1	½	-	1	2¼	1½	2	15½
Sep	2	1	1	--	-	1¾	1	¼	..	--	1	--	1	2	-	2½	3	1½	1	1½	1	2½	3	1½	10½
Oct	--	--	--	--	--	--	-	1	2½	1½	2	2	2¼	4	7	7¼	8¼	9¼	8	5¼	4	3½	3	1½	76½
Nov.	3	3	2	¼	..	--	1¼	½	1	·	--	2½	5¼	5½	8¼	7¼	8¼	9¼	8	5¼	4	3½	4	3½	73½
Dec	1	1	1	1	·	-	..	½	¾	2¼	1	6	8½	12	14½	11½	8½	7½	5	2	2	..	3½	1	110½
6 years	16½	12½	7	5¼	3	5	7½	5¼	8½	6¼	9¼	21½	43¼	64¼	80	97¼	77½	[illegible]	85½	63¼	51½	35¼	44¼	33	872
annual average	2.75	2.08	1.17	.96	.50	.83	1.25	.87	1.42	1.13	1.63	3.54	7.29	10.71	13.33	16.29	12.96	14.17	14.25	10.63	8.46	5.96	7.46	5.50	145.33

2. Lightning only

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	N	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	M	Total
	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours
Jan	1	1	1	1	1	1	-	..	..	..	..	..	..	1	1	1	2½	3½	10¼	28¼	37½	23¼	13½	6	127½
Feb	3	1	..	-	..	-	-	..	..	..	..	..	..	·	·	·	2	3	15½	27½	34¼	33½	26½	17	[illegible]
Mar	3½	..	..	..	..	-	-	..	-	-	-	..	..	..	¼	1½	3	6	19½	33	34¼	25½	20¼	13¾	[illegible]
Apr		..	..	..	-	-	-	..	-	¼	..	-	-	..	-	-	2¼	7½	18	19¾	23¼	16½	14	5¾	107
May	·	..	..	..	-	-	-	..	-	-	-	-	-	..	-	-	3	4¼	4¼	4	2	1	2		42
Jun	·	..	..	-	-	-	-	-	-	-	-	-	..	..	..	-	..	..		2¼	1	-		-	·
Jul	..	-	..	-	-	-	-	-	-	-	-	-	-	-	-	-	-		½	1½	4¼	3	3	1½	1½
Aug	..	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	¼	3¼	4½	4½	2¾	3¼	1	19½
Sep	1	..	..	..	¼	-	-	-	-	..	-	-	..	..	-	-	-	2½	6¼	6¼	6	4¾	2¼	3	32
Oct	2	1	..	-	-	-	-	-	-	-	-	-	-	..	..	..	½	2½	10¼	13	14	11	10½	8	73
Nov	3	1¾	1	..	-	-	-	-	-	-	-	-	-	..	-	-	-	-	10½	19½	20¼	17¼	11¼	7	92½
Dec	1	..	..	-	-	-	-	-	-	-	-	-	1	1	¼		..	2	7¼	20¼	25½	23½	20	10¼	112½
6 years	14½	4¾	2	1	1¼	1	-	-	-	-	-	-	1	2	2	2½	10¼	31¼	107½	160¼	203½	163¼	126	75½	929¼
annual average	2.42	·80	·33	·17	·21	·17				·04			·17	·33	·33	·42	1.71	5.21	17.92	30.04	33.88	27.21	21.00	12.54	154.88

3. Thunder, Thunderstorms, and Lightning.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	N	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	M	Total
	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours	hours
annual average	5.17	2.88	1.50	1.13	.71	1.00	1.25	.87	1.42	1.17	1.63	3.54	7.46	11.04	13.67	16.71	14.67	19.56	32.17	40.67	42.33	33.17	28.46	18.04	300.21

Table 18. The Diurnal Variation of Rainfall at Kenilworth, Kimberley, in Different Seasons 1897 to 1902

	Quantity				Frequency				Rate			
	Nov to Jan	Feb to Apr	May to July	Aug to Oct	Nov to Jan.	Feb to Apr	May to July	Aug to Oct	Nov to Jan	Feb to Apr	May to July	Aug to Oct
Hour ending	inches	inches	inches	inches	hours	hours	hours	hours	in per hour	in per hour	in per hour	in per hour
I	1401	1834	066	612	18	33	11	12	078	056	006	051
II	1040	2049	522	537	23	36	11	12	045	057	048	045
III	1715	2436	162	357	24	28	12	12	071	087	0·0	030
IV	·585	1220	586	295	17	26	11	12	034	047	053	025
V	1583	748	330	213	19	30	13	9	083	025	025	024
VI	852	877	454	424	18	20	17	5	047	044	027	085
VII	356	1201	305	242	16	20	12	5	022	060	025	048
VIII	548	949	295	110	18	21	8	6	030	045	037	018
IX	611	873	239	115	13	24	6	8	047	036	040	014
X	697	653	175	313	11	22	7	6	063	030	025	052
XI	289	852	184	523	13	22	5	6	022	039	037	087
Noon	979	851	268	275	16	18	6	8	061	047	045	034
XIII	1513	945	361	163	22	27	9	7	069	035	040	023
XIV	1985	1796	141	585	34	33	9	8	058	054	016	073
XV	2153	2735	229	730	48	46	7	10	045	059	033	073
XVI	3790	2328	845	984	55	44	9	17	069	053	094	058
XVII	3503	2558	098	2219	46	43	9	21	076	059	011	106
XVIII	1711	3128	184	2918	38	42	9	21	045	074	020	139
XIX	2968	1671	261	498	47	49	12	14	063	034	022	036
XX	2539	3244	227	633	44	52	12	19	058	062	019	033
XXI	1345	2256	374	1029	39	54	11	16	035	042	034	064
XXII	824	1.788	381	1107	23	43	16	17	036	042	024	065
XXIII	1349	1871	177	801	31	43	12	21	043	044	015	038
Midnight	3279	1808	094	775	26	37	12	21	126	049	008	037
Totals (6 years)	37615	40.671	7158	16458	659	813	246	293	057	050	029	056
Day	18135	18869	1324	9177	330	362	96	123	055	052	035	075
Night	19480	21802	5834	7281	329	451	150	170	059	048	026	043

Table 20. Some Harmonic Constants in the Diurnal Curves of ——

	1. Rainfall at Kenilworth (Kimberley).						2 Thunderstorms at —		
	Inches. Year.	Hours Year.	Hours Summer.	Hours. Autumn	Hours Winter	Hours Spring	Kimberley Hours Year	Basle Hours. Year	Vienna Hours. Year.
V_1	176°4	168°4	188°5	165°8	95°8	153°2	199°4	207°8	213°8
V_2	347°3	320°3	332°9	292°1	299°6	304°3	336°2	349°0	358°0
V_3	107°2	171°8	160°0	199°0	234°4	93°5	148°6	244°6	144°0
V_4	231°9	308°0	340°6	327°5	137°8	220°4	50°9	335°6	343°3
u_1	2.388	36.585	15.419	14.487	3.309	6.951	6.924	40.2	54.[illegible]
u_2	1.172	10.599	7.305	2.206	1.191	427	1.975	12.0	30.1
u_3	679	4.530	2.543	1.007	1.804	1.578	1.001	4.1	12.6
u_4	166	4.495	2.755	3.336	682	1.992	215	2.9	5.9

Table 21
Monthly Deviation of the Wind from the Mean.

	Deficient Rainfall				Abundant Rainfall			
	N—ENE	E—SSE	S.—WSW	W—NNW	N—ENE	E—SSE	S—WSW	W—NNW
	hours	hours	hours	hours	hours	hours	hours	hours
Jan	—13	—14	+ 5	+18	+24	+27	—13	—37
Feb	— 5	+ 1	— 1	+ 4	+30	— 8	+ 6	—33
Mar.	—14	0	+10	+ 3	+26	0	—20	— 4
Apr	—10	—51	+ 6	+51	+ 6	+24	— 3	—27
May	—21	— 6	+ 6	+19	+42	+11	—14	—38
Jun	+ 4	+ 2	— 9	+ 3	— 8	— 4	+21	— 5
Jul	+ 4	—17	+17	+14	— 7	+38	—33	—25
Aug	0	0	0	0	0	0	0	0
Sep	—11	— 3	+14	— 2	+20	+ 9	—29	+ 2
Oct	— 5	+34	—35	+ 2	+ 2	—34	+34	— 2
Nov	— 1	—37	+12	+27	+ 2	+73	—22	—51
Dec.	0	+ 6	+ 6	—10	— 1	—11	— 8	+22
Year	—39	—75	+21	+95	+76	+150	—41	—190

Table 22. Approximate Temperature of falling Rain, + the vertical Space it describes, at Kenilworth, Kimberley.

	Mean Monthly Air Temp	Mean Monthly Dew-Point Temp	Mean Dew-Point Temp. after Rain	Observed Frequency	Computed Mean Base-Altitude of Rain Cloud
	°	°	°	times	feet
Jan	74 0	52 1	63.3	48	2,470
Feb	74 1	52 9	61 5	34	2,910
Mar.	69 1	54 5	60 8	49	1,915
Apr	62 5	49 5	58 5	25	925
May	54.7	39 2	48 8	6	1,360
Jun.	49.1	34 5	42.1	5	1,615
Jul	48.8	33 7	45 2	6	830
Aug	54 5	34 7	52.1	1	550
Sep.	61 1	38.5	50 5	21	2,445
Oct.	65 5	42 2	55 6	16	2,280
Nov	70 5	43 5	59 0	17	2,650
Dec.	74 7.	49 8	60 6	28	3,250

Table 23. Shewing the Relationship between the percentages of Cloud + the computed Altitudes of the Plane of Condensation [illegible] Kimberley

	Cloud						Plane of Condensation					
	A	B	C	D	E	Average	A	B	C	D	E	Average
	%	%	%	%	%	%	feet	feet	feet	feet	feet	feet
Jan.	59	45	34	31	30	41	2,838	5,538	5,331	5,123	6,438	5,054
Feb	51	49	42	38	33	43	3,739	4,477	4,362	6,023	5,908	4,902
Mar	41	39	38	32	32	36	3,069	3,415	2,838	3,692	3,854	3,374
Apr	45	39	30	28	24	33	2,331	2,792	2,861	3,646	3,462	3,018
May	30	26	20	16	8	20	3,000	2,515	3,992	4,431	4,015	3,591
Jun	25	23	17	16	9	18	3,438	3,208	3,115	3,092	3,923	3,355
Jul.	32	24	17	9	6	18	2,400	2,608	3,900	4,131	4,385	3,485
Aug	25	21	17	16	12	18	4,154	4,223	4,869	4,731	4,823	4,560
Sep.	36	34	31	23	17	28	4,038	3,762	5,815	6,462	6,023	5,220
Oct	48	38	37	24	24	34	4,362	5,031	6,300	5,538	5,654	5,377
Nov	35	31	29	27	16	27	5,469	6,323	6,023	6,900	6,462	6,235
Dec	41	39	37	36	33	37	4,431	6,162	6,415	6,439	5,377	5,765
Mean	39	34	29	25	20	29	3,606	4,171	4,652	5,017	5,027	4,695
	F	G	H	J	K		F	G	H	J	K	
	%	%	%	%	%		feet	feet	feet	feet	feet	
Jan.	59	21	38	45	30		2,838	5,123	5,331	5,518	6,438	
Feb	51	42	49	33	38		3,739	4,362	4,477	5,908	6,025	
Mar.	36	41	39	32	32		2,838	3,069	3,415	3,192	3,854	
Apr	45	39	30	24	28		2,331	2,792	2,861	3,462	3,646	
May	28	30	20	8	16		2,515	3,000	3,992	4,015	4,431	
Jun	16	17	23	25	9		3,092	3,115	3,208	3,438	3,923	
Jul	32	24	17	9	6		2,400	2,608	3,900	4,131	4,385	
Aug	25	21	16	12	17		4,154	4,223	4,731	4,823	4,869	
Sep.	34	36	31	17	23		3,762	4,038	5,815	6,023	6,462	
Oct	48	38	24	24	37		4,362	5,011	5,538	5,654	6,300	
Nov.	35	29	31	16	27		5,469	6,023	6,323	6,462	6,900	
Dec.	41	33	39	37	36		4,431	5,377	6,162	6,415	6,439	
Mean	38	32	30	24	25		3,494	4,063	4,646	4,903	5,306	

lected Stations

	Jul.	Aug.	Sep.	Oct	Nov	Dec	Year
	in.	in.	in.	in.	in.	in.	inches
3	.32	.44	.39	.70	.96	1.00	11.66
4	.37	.42	.29	.84	1.03	1.36	13.86
1	.41	.49	.64	.88	1.14	1.37	15.00
7	.31	.42	.50	.80	.96	1.46	14.17
7	.35	.45	.57	1.02	1.27	1.65	14.88
1	.32	.55	.69	1.09	1.08	1.70	16.59
4	.39	.50	.61	1.18	1.35	1.65	15.33
5	.53	.78	.75	1.15	1.64	1.84	16.54
2	.33	.45	.56	.90	1.28	1.43	13.68
4	.47	.54	.91	1.16	1.42	2.23	18.44
8	.64	.77	.82	1.40	1.71	2.22	19.80
7	.40	.53	.61	1.01	1.26	1.63	15.45
3	.05	.18	.10	.60	.14	.19	3.31
9	.13	.10	.13	.46	.23	.54	5.79
0	.09	.09	.21	.83	.66	.80	7.70
6	.14	.12	.13	.36	.49	.57	6.62
5	.10	.12	.14	.56	.38	.53	5.85
5	.10	.18	.29	.67	.69	.89	10.25
6	.16	.29	.35	.91	1.02	1.80	14.83
9	.18	.30	.30	.74	1.01	2.41	14.99
2	.16	.31	.27	.62	1.00	2.22	14.35
5	.27	.24	.40	.85	.98	1.48	13.62
3	.28	.31	.40	.92	1.66	3.29	19.57
1	.34	.36	.91	1.19	1.72	2.44	18.47
7	.21	.28	.42	.84	1.15	2.08	15.15

6	.28	.43	.58	1.09	1.85	2.45	20.32
3	.32	.48	.50	1.07	1.64	1.70	19.41
2	.44	.71	.74	1.41	1.47	3.05	20.86
2	.37	.60	.71	1.82	2.22	2.86	23.37
6	.54	1.03	.82	1.23	1.59	2.84	22.73
9	.26	.55	.87	2.04	3.46	2.83	25.18
8	.69	.99	1.37	2.38	3.55	3.38	31.60
9	.41	.68	.80	1.58	2.25	2.72	23.35
6	.23	.64	.82	2.58	3.16	3.41	27.71
7	.20	1.32	1.93	3.21	4.20	7.42	39.77
1	.16	1.14	1.31	2.70	3.97	5.43	31.14
2	.18	1.07	1.35	2.57	4.96	6.03	35.38
6	.77	1.95	3.73	4.94	4.42	4.51	39.80
9	.78	1.42	3.64	5.27	5.37	5.53	41.06
0	.39	1.26	2.13	3.71	4.35	5.72	35.81

Table 24. Computed variation in the Level of the First Plane of Condensation

Diurnal			Monstrual		
Hour	Complement of the Dew-Point	Condensation Level	Month	Complement of the Dew-Point	Condensation Level
	°	feet	At XV	°	feet
0	13.8	3,185	Jan	33.8	7,800
I	12.4	2,862	Feb	34.9	8,054
II	11.3	2,608	Mar.	27.7	6,393
III	10.7	2,469	Apr	25.7	5,931
IV	10.1	2,331	May	29.2	6,738
V	9.3	2,146	Jun	27.2	6,277
VI	8.9	2,054	Jul	27.8	6,416
VII	10.3	2,377	Aug.	33.9	7,823
VIII	14.8	3,415	Sep	37.0	8,538
IX	19.4	4,477	Oct	36.7	8,467
X	23.4	5,400	Nov	41.1	9,485
XI	27.0	6,231	Dec	38.3	8,838
Noon	29.6	6,831			
XIII	31.7	7,315	At VI	°	feet
XIV	32.5	7,500	Jan	9.6	2,215
XV	32.8	7,569	Feb	8.8	2,031
XVI	32.0	7,385	Mar	4.6	1,062
XVII	28.0	6,462	Apr	4.1	946
XVIII	23.6	5,446	May	6.9	1,592
XIX	20.4	4,662	Jun	6.9	1,592
XX	18.4	4,246	Jul	7.8	1,800
XXI	17.0	3,923	Aug.	9.7	2,238
XXII	15.8	3,646	Sep.	11.3	2,608
XXIII	14.5	3,346	Oct	11.2	2,585
			Nov	13.9	3,208
			Dec	12.3	2,838

Table 25. Shewing the Mean Monthly & Annual Rainfall at Selected Stations in South Africa chiefly for the 22 years 1880 — 1901

Stations	Ref. No.	No. of Years	Lat. S	Long. E	Height	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
I. Cape Peninsula:—			° '	° '	feet	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	inches
Observatory	1	22	33 56	18 29	30	.82	.61	1.12	2.16	4.17	4.07	4.12	3.53	2.50	1.85	1.03	.87	26.84
Disa Head	2	20	33 59	18 24	2,496	1.15	1.26	1.75	3.78	5.66	5.77	5.92	4.66	3.54	3.12	2.23	1.69	40.53
Taai Kopje	3	20	33 58	18 25	3,100	2.02	1.93	2.66	5.29	8.92	8.74	9.25	7.69	5.46	4.64	3.20	2.89	62.68
Wynberg	4	22	34 0	18 28	235	.99	.71	1.34	2.79	6.50	6.77	6.99	6.07	4.10	2.99	1.33	1.15	41.73
Simonstown	5	21	34 12	18 26	12	.93	.95	1.40	2.44	4.33	4.36	4.59	3.64	2.84	2.32	1.48	1.06	30.34
Average						1.18	1.09	1.65	3.29	5.92	5.94	6.17	5.12	3.69	2.98	1.85	1.53	40.42
II South-West:—																		
Klapmuts	6	18	33 48	18 51	555	.87	.52	.98	2.50	4.33	4.48	4.19	3.93	2.61	2.18	1.35	.71	28.64
Stellenbosch	7	22	33 56	18 51	400	.68	.63	.92	2.17	4.36	3.94	3.92	3.71	2.50	2.11	1.19	.85	26.98
Paarl	8	22	33 45	18 57	500	.70	.63	.90	3.01	4.94	5.39	4.85	5.00	2.92	2.31	1.19	.81	32.65
Wellington	9	22	33 38	18 59	400	.79	.73	.74	2.41	3.76	4.18	3.43	3.42	2.34	1.99	.83	.72	25.34
Tulbagh	10	22	33 18	19 8	490	.49	.55	.54	1.74	2.85	2.27	2.16	2.28	2.10	1.55	.84	.68	18.05
Ceres	11	22	33 22	19 19	1,493	1.03	.58	.91	3.18	6.80	5.98	5.21	5.17	4.30	3.48	1.62	1.43	39.69
Rocklands	12	17	33 6	19 20	2,500	.57	.40	.51	2.17	4.26	3.49	2.90	3.12	2.27	1.69	.85	.84	23.07
Caledon	13	22	33 13	19 25	760	1.00	.85	1.25	1.99	2.59	2.14	2.25	2.28	1.65	1.54	1.27	.84	19.63
Worcester	14	22	33 39	19 26	780	.38	.36	.47	1.08	1.46	1.51	1.30	1.40	1.14	.86	.40	.54	10.90
Robertson	15	22	33 47	19 53	600	.65	.82	.81	1.35	1.37	1.23	1.23	1.13	1.17	.97	.83	.63	12.20
Montagu	16	18	33 48	20 8	727	.52	.62	.46	1.09	2.02	1.19	1.35	1.43	1.25	.84	.79	.30	11.88
Average						.70	.61	.77	2.06	3.52	3.26	2.98	2.99	2.20	1.78	1.01	.76	22.64
III West Coast:—																		
Port Nolloth	17	22	29 16	16 52	40	.05	.06	.13	.26	.54	.28	.33	.33	.17	.13	.12	.06	2.46
O'okiep	18	19	29 36	17 52	3,036	.18	.36	.49	.88	1.18	.82	.87	.87	.56	.61	.27	.16	7.26
Springbokfontein	19	22	29 40	17 53	3,200	.17	.35	.60	.77	1.45	1.10	1.08	1.13	.71	.75	.32	.14	8.57
Garies	20	13	30 33	18 1	830	.04	.05	.12	.70	.81	.70	.96	.87	.47	.43	.32	.20	5.66
Malmesbury	21	22	33 28	18 43	460	.52	.48	.57	1.61	2.74	2.59	2.35	2.34	1.83	1.27	.70	.50	17.52
Piquetberg	22	22	32 54	18 43	700	.51	.58	.43	1.77	3.34	2.84	2.80	2.49	2.38	1.88	.89	.68	20.60
Van Rhyn's Dorp	23	17	31 35	18 44	400	.07	.22	.18	.84	1.09	.89	.88	.70	.62	.43	.21	.07	6.20
Clanwilliam	24	22	32 10	18 53	245	.23	.32	.26	.77	1.51	1.35	1.10	.98	.92	.64	.32	.19	8.60
Average						.22	.30	.35	.95	1.58	1.32	1.30	1.21	.96	.77	.39	.25	9.61
IV South Coast, W.—			° '	° '	feet	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	inches
Cape L'Agulhas	25	20	34 33	20 1	55	.72	1.4	1.01	1.64	2.15	2.02	1.92	1.74	1.24	1.17	.70	.68	15.64
Bredasdorp	26	22	34 33	20 2	250	.99	1.21	1.64	1.65	2.17	1.75	1.87	2.17	1.46	1.56	1.41	1.04	18.91
Swellendam	27	21	34 4	20 27	500	2.72	2.42	2.96	3.18	3.49	2.07	2.09	2.51	2.84	2.95	2.47	2.44	32.15
Heidelberg	28	21	34 5	20 58	100	1.06	1.23	1.71	1.82	1.86	1.20	1.00	1.45	1.53	1.60	1.34	.96	16.75
Riversdale	29	22	34 6	21 16	100	1.11	1.21	1.80	1.80	1.61	1.09	1.14	1.28	1.56	1.27	1.40	1.08	16.35
Mossel Bay	30	22	34 11	22 9	105	1.07	1.38	1.54	2.09	1.70	1.13	1.18	1.35	1.50	1.50	1.28	1.32	17.03
George	31	22	33 57	22 29	620	3.28	3.15	3.41	2.72	2.73	1.93	1.46	2.43	2.86	2.69	3.08	2.67	32.40
Ezeljagt	32	18	33 48	22 47	1900	1.25	.68	1.09	1.51	1.44	1.41	.53	1.57	1.68	1.19	1.73	.67	14.76
Average						1.52	1.49	1.90	2.05	2.14	1.58	1.40	1.81	1.83	1.74	1.68	1.36	20.50
IV South Coast, E.—																		
Knysna	33	21	34 3	23 3	30	2.19	2.03	2.32	1.96	2.36	2.16	2.19	2.44	2.64	2.33	2.39	2.24	27.26
Storms River	34	18	33 58	23 52	580	3.84	3.47	3.47	3.41	3.63	2.51	2.75	3.71	4.26	3.96	3.57	3.93	42.52
Humansdorp	35	22	34 2	24 46	360	1.72	1.58	2.37	2.26	2.58	1.75	1.82	2.51	2.21	2.20	2.65	1.95	25.79
Cape St. Francis	36	21	34 12	24 50	20	1.47	.84	1.72	2.18	3.02	2.12	2.74	3.13	2.33	2.27	2.05	1.76	25.65
Van Staadens	37	21	33 52	25 16	1522	2.43	2.17	2.40	2.50	2.62	1.72	2.09	2.59	3.01	2.85	2.89	2.50	29.76
Uitenhage	38	22	33 47	25 24	190	1.00	1.23	1.84	1.64	1.33	.91	.69	1.27	1.33	1.38	2.07	1.46	16.15
Dunbrody	39	15	33 30	25 28	200	1.40	1.08	1.82	1.69	1.17	.84	.71	.93	1.32	1.34	1.94	1.90	16.14
Port Elizabeth	40	22	33 58	25 37	181	1.23	.83	1.51	1.77	2.40	1.40	1.60	2.01	2.13	1.70	2.00	1.66	20.22
Walmer Heights	41	21	33 59	25 36	450	1.93	1.60	2.05	2.38	3.15	1.90	2.30	3.03	2.97	2.94	3.08	2.58	29.91
Tankatara	42	22	33 41	25 42	100	1.00	1.23	1.80	1.73	1.39	1.35	.77	1.32	1.50	1.45	2.01	1.77	17.32
Average						1.82	1.61	2.13	2.15	2.36	1.69	1.77	2.29	2.37	2.24	2.47	2.17	25.07
V. Southern Karroo, W.—																		
Touws River	43	20	33 20	20 3	2,500	.52	.48	.72	1.03	1.25	1.16	1.09	.87	.88	.64	.30	.26	9.20
Ladismith	44	21	33 29	21 17	1,860	1.12	1.27	1.44	1.69	1.31	.80	.87	.97	1.11	1.14	.90	.78	13.60
Amalienstein	45	22	33 29	21 29	1,570	1.?7	1.30	1.37	1.42	1.25	.73	.75	.80	1.03	1.26	.88	.74	12.60
Calitzdorp	46	22	33 32	21 41	750	.73	.97	1.17	1.04	.65	.11	.29	.59	.67	.77	.65	.50	8.34
Average						.91	1.01	1.17	1.30	1.11	.75	.75	.81	.92	.95	.68	.57	10.93
V. Southern Karroo, E.—																		
Oudtshoorn	47	21	33 35	22 13	1,090	.68	.83	.99	.94	1.12	.61	.52	.94	.94	.75	.65	.46	9.44
Uniondale	48	22	33 39	23 9	2240	.84	1.00	1.51	1.20	1.53	1.11	1.07	1.54	1.21	1.02	1.21	.70	13.94
Kleinpoort	49	20	33 20	24 53	1,900	1.19	.88	2.04	1.13	.77	.55	.36	.62	1.10	1.05	1.27	1.29	12.24
Glenconnor	50	17	33 24	25 10	730	1.48	.92	1.63	1.14	.85	.63	.36	.81	.97	.89	1.83	1.41	12.92
Average						1.05	.91	1.54	1.10	1.07	.73	.58	.98	1.05	.93	1.24	.96	12.14
VI. West-Central Karroo, W.—			° '	° '	feet	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	inches
Matjesfontein	51	18	33 14	20 36	2,970	.37	.46	.58	.83	.77	.63	.46	.48	.60	.57	.24	.34	6.33
Prince Albert	52	22	33 11	22 2	2,120	.61	.86	1.25	1.07	1.37	.68	.25	.60	.65	.67	.57	.58	9.15
Zwartberg Pass	53	12	33 21	22 34	5,200	2.69	2.01	1.78	2.55	2.18	2.01	1.20	1.56	2.64	2.33	2.21	1.54	24.70
Average						1.22	1.11	1.20	1.48	1.44	1.11	.64	.88	1.30	1.19	1.01	.82	13.39
VI. West-Central Karroo, E.—																		
Beaufort West	54	22	32 21	22 34	2,850	1.08	1.20	1.33	.83	.59	.21	.21	.34	.50	.54	.92	.94	8.70
Camfer's Kraal	55	22	32 14	23 3	3,012	1.37	1.06	1.78	.95	.63	.21	.13	.23	.47	.43	.79	.80	8.85
Lower Nelspoort	56	22	32 11	23 4	3,100	1.59	1.31	2.05	.97	.72	.30	.24	.32	.57	.49	.95	1.02	10.53
Willowmore	57	22	33 17	23 30	2,760	1.14	.91	1.45	.90	.84	.57	.29	.48	.38	.65	.82	.99	9.42
Average						1.30	1.12	1.65	.91	.69	.32	.22	.34	.48	.53	.87	.95	9.38
VII. East-Central Karroo—																		
Aberdeen	58	22	32 28	24 3	2,400	1.90	1.73	2.33	.87	.71	.27	.31	.50	.83	.90	1.35	1.37	13.07
Rietfontein	59	33	32 59	23 48	2,270	1.04	1.55	1.70	1.00	.87	.46	.36	.54	.59	.95	1.06	.97	11.10
Winterhoek	60	22	32 15	24 28	2,800	1.98	2.33	3.13	1.28	1.32	.49	.56	.79	1.36	1.43	2.12	1.91	18.70
Graaff Reinet	61	22	32 16	24 32	2,500	1.78	1.91	2.78	1.16	1.31	.41	.52	.76	1.12	1.25	1.66	1.60	16.26
Roodebloem	62	20	32 9	24 36	2,500	1.48	1.77	2.19	.78	.89	.29	.50	.53	.74	.81	1.10	1.35	12.43
Goliad's Kraal	63	30	32 8	24 42	3,500	1.71	2.20	2.54	1.22	1.08	.31	.55	.74	.62	1.26	1.49	1.36	15.08
Wellwood	64	22	31 59	24 38	4,000	1.84	1.84	2.92	1.29	.98	.44	.43	.59	.70	.87	1.35	1.40	14.70
Jansenville	65	22	32 56	24 40	?	1.50	1.21	1.88	.94	.69	.31	.22	.46	.73	.66	1.33	1.32	11.26
Cranemere	66	20	32 30	25 0	2,750	1.52	1.68	2.24	1.11	.99	.36	.55	.72	.99	.98	1.29	1.53	13.94
Walsingham	67	18	32 28	25 10	?	2.26	1.84	2.33	1.30	1.30	.48	.73	.76	1.13	1.16	1.45	1.62	16.35
Somerset East	68	21	32 44	25 35	2,400	3.30	3.34	3.49	2.07	1.41	.72	.76	1.02	1.96	2.33	2.78	3.03	26.22
Middleton	69	20	32 57	25 49	1,672	1.61	1.68	1.98	1.49	1.09	.52	.53	.72	.75	1.02	1.54	1.72	14.65
Average						1.83	1.92	2.46	1.21	1.05	.42	.50	.68	.96	1.14	1.54	1.60	15.31
VIII. Northern Karroo, W.—																		
Calvinia	70	21	31 29	19 46	3,100	.31	.49	.68	1.15	1.12	.89	.79	.82	.54	.53	.42	.18	7.92
Middlepost	71	17	31 58	20 7	?	.34	.36	.85	.86	.61	.36	.30	.33	.36	.30	.34	.19	5.20
Sutherland	72	21	32 25	20 42	4,776	.56	.80	1.03	1.26	1.43	.89	.74	.73	.66	.70	.62	.50	9.92
Fraserburg	73	22	31 54	21 31	4,200	.81	.88	1.15	1.04	.67	.44	.23	.34	.32	.39	.58	.36	7.22
Carnarvon	74	22	30 58	22 8	4,060	1.36	1.35	1.43	1.15	.62	.34	.15	.33	.35	.52	.62	.52	8.74
Hagenaar's Kraal	75	17	31 48	22 48	4,500	1.50	1.67	1.98	.98	.79	.23	.27	.23	.26	.65	.89	1.15	10.70
Brakfontein	76	22	31 49	23 2	3,947	1.48	1.53	2.06	.96	.68	.32	.27	.29	.39	.59	.95	1.02	10.54
Victoria West	77	22	31 25	23 7	4,100	1.31	2.18	1.76	1.09	.81	.41	.19	.33	.50	.67	.77	1.02	11.03
Average						.96	1.16	1.37	1.06	.84	.48	.37	.42	.44	.54	.65	.62	8.91

Table 25.— Continued

Stations	Ref. No.	No. of Years	Lat. S.	Long. E.	Height	Jan	Feb	Mar	Apr.	May	Jun.	Jul	Aug	Sep.	Oct	Nov	Dec	Year
VIII Northern Karroo, E.:—			° '	° '	feet	in.	in.	in.	in.	...	in.	in.	in.	in.	in.	in.	in.	inches
Murraysburg	78	22	31 57	23 48	3,800	1.35	1.94	2.13	1.08	1.02	.33	.32	.44	.39	.70	.96	1.00	11.66
Richmond	79	21	31 25	23 57	4,700	1.79	2.28	2.30	1.43	1.19	.54	.37	.42	.29	.84	1.03	1.36	13.86
Hanover	80	22	31 3	24 26	4,500	1.77	2.37	2.49	1.83	1.10	.51	.41	.49	.64	.88	1.14	1.37	15.00
Philipstown	81	22	30 25	24 30	4,500	1.80	2.22	2.62	1.51	1.08	.47	.31	.42	.50	.80	.96	1.46	14.17
Middelburg	82	22	31 30	25 0	4,095	2.30	2.36	2.55	1.23	.77	.37	.35	.45	.57	1.02	1.27	1.65	14.88
Colesburg	83	22	30 43	25 7	4,470	2.41	2.61	2.76	1.64	1.12	.61	.32	.55	.69	1.09	1.08	1.70	16.59
Cradock	84	22	32 11	25 38	2,850	2.42	2.40	2.32	1.29	.78	.44	.39	.50	.61	1.18	1.35	1.65	15.33
Witmoss	85	16	32 32	25 45	2,396	2.41	1.96	2.63	1.59	.87	.35	.53	.78	.75	1.15	1.64	1.84	16.54
Varsch Vlei	86	18	31 40	25 45	5,400	2.13	2.13	1.88	1.30	.56	.42	.33	.45	.56	.70	1.28	1.43	13.68
Steynsburg	87	22	31 18	25 49	4,850	2.61	2.83	3.20	1.56	.96	.54	.47	.54	.91	1.16	1.42	2.23	18.44
Tarkastad	88	22	32 0	26 15	4,300	3.01	2.82	3.27	1.54	1.04	.58	.64	.77	.82	1.40	1.71	2.22	19.80
Average						2.18	2.36	2.56	1.46	.98	.47	.40	.53	.61	1.01	1.26	1.63	15.45
IX Northern Border, W.:—																		
Pella	89	22	29 2	19 9	1,800	.21	.39	.68	.41	.23	.13	.05	.18	.10	.60	.14	.19	3.31
Kenhardt	90	22	29 18	21 9	2,700	.56	1.05	1.15	.90	.35	.19	.13	.10	.13	.46	.23	.54	5.79
Upington	91	15	28 26	21 15	2,800	.80	.90	1.69	.95	.58	.10	.09	.09	.21	.83	.66	.80	7.70
Van Wyk's Vlei	92	16	30 23	21 50	3,300	.69	1.16	1.41	.86	.52	.16	.14	.12	.13	.36	.49	.57	6.62
Average						.56	.88	1.23	.78	.42	.15	.10	.12	.14	.56	.38	.53	5.85
IX Northern Border, E.:—																		
Prieska	93	22	29 39	22 45	3,300	1.26	1.38	2.21	1.71	.62	.25	.10	.18	.29	.67	.69	.89	10.25
Griquatown	94	17	28 52	23 17	3,560	2.03	2.26	2.70	1.86	.89	.56	.16	.29	.35	.91	1.02	1.80	14.83
Campbell	95	17	28 45	23 43	4,100	2.19	2.58	2.68	1.79	.52	.29	.18	.30	.30	.74	1.01	2.41	14.99
Avoca	96	18	29 4	23 53	3,900	2.14	2.16	2.98	1.49	.68	.32	.16	.31	.27	.62	1.00	2.22	14.35
Hopetown	97	22	29 36	24 6	3,600	2.08	1.81	2.92	1.33	.91	.35	.27	.24	.40	.85	.98	1.48	13.62
Barkly West	98	19	28 30	24 30	3,800	3.12	3.19	3.43	1.81	.73	.43	.28	.31	.40	.92	1.66	3.29	19.57
Kimberley	99	26	28 43	24 46	4,040	2.80	2.73	3.29	1.50	.78	.41	.34	.36	.71	1.19	1.72	2.44	18.45
Average						2.23	2.30	2.89	1.64	.73	.37	.21	.28	.42	.84	1.15	2.08	15.15
X South-East:—																		
Alicedale	100	21	33 20	26 5	910	1.77	1.20	1.59	1.51	1.40	.83	.88	1.00	1.34	1.35	1.83	1.34	16.04
Bedford	101	22	32 41	26 6	2,460	3.28	3.50	3.99	2.27	1.50	.75	.89	1.12	1.75	2.52	3.11	2.99	27.68
Cullendale	102	17	32 39	26 12	?	3.20	2.94	3.44	2.31	1.12	.58	.75	.95	1.72	2.35	2.75	3.16	25.27
Atherstone	103	20	33 19	26 23	2,250	2.45	2.07	2.44	1.99	1.65	.88	1.06	1.24	1.97	2.14	2.27	2.23	22.39
Salem	104	22	33 28	26 30	500	2.04	1.81	2.25	2.16	1.67	1.05	1.11	1.63	1.84	2.13	2.55	2.22	22.46
Grahamstown	105	22	33 18	26 32	1,800	2.54	2.70	2.98	2.21	1.99	1.18	1.16	1.54	2.18	2.74	3.20	2.51	26.94
Fort Beaufort	106	22	32 46	26 37	1,500	2.68	2.70	3.33	1.95	1.26	.52	.73	.90	1.64	1.95	2.61	2.12	22.39
Continued			° '	° '	feet	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Lower Katberg	107	19	32 29	26 40	3,380	6.18	5.37	5.08	2.98	1.79	.83	1.06	1.70	2.82	4.53	5.03	5.81	43.20
Seymour	108	21	32 33	26 47	2,600	2.74	2.77	3.44	1.83	1.60	1.10	1.10	1.27	1.37	1.84	2.56	2.44	23.96
Alice	109	22	32 47	26 50	1,700	2.70	2.88	3.14	2.02	1.49	.89	1.02	1.16	1.59	2.13	2.65	2.53	24.20
Lovedale	110	19	32 46	26 51	1,720	2.94	2.84	2.94	1.96	1.55	.98	1.09	1.08	1.63	1.94	2.55	2.46	23.98
Port Alfred	111	22	33 34	26 54	110	1.93	1.63	2.29	2.49	2.43	1.75	1.64	2.30	2.85	2.47	2.99	2.15	26.93
Hogsback	112	17	32 36	26 55	3,750	6.21	6.12	5.85	3.39	2.27	1.23	1.56	2.33	2.44	5.13	4.89	6.07	47.49
Peddie	113	21	33 13	27 7	500	2.05	2.03	2.61	2.14	1.76	1.21	1.14	1.62	2.12	2.45	2.74	2.18	24.05
Cathcart	114	22	32 18	27 9	3900	4.04	4.28	4.66	2.19	.83	.49	.77	.88	1.20	2.49	3.17	3.50	28.50
Evelyn Valley	115	15	32 35	27 15	4250	8.46	6.32	6.81	4.43	2.81	1.87	1.53	2.92	4.69	6.46	6.66	6.54	59.50
Thomas River	116	22	32 32	27 17	3,565	2.97	3.04	3.41	1.71	.83	.55	.57	.93	1.01	1.70	2.38	2.32	21.42
Perie Forest	117	20	32 27	27 18	1,850	5.19	4.41	4.72	3.11	1.66	1.11	.96	1.58	3.21	4.36	5.24	4.29	39.84
Kologha	118	17	32 31	27 22	2,200	5.42	5.05	4.82	2.87	1.26	.85	.85	1.58	1.99	3.70	4.61	5.41	38.40
King Williams T.	119	22	32 52	27 23	1,315	2.39	2.97	2.91	2.23	1.38	.83	.83	1.40	2.00	2.39	2.92	2.54	24.79
Stutterheim	120	19	32 34	27 27	2,945	4.00	3.82	3.85	2.42	.99	.73	.62	1.30	1.70	2.88	3.49	3.65	29.45
Dohne	121	20	32 32	27 27	3,040	3.19	3.35	3.26	1.64	1.14	.46	.61	1.07	1.42	2.81	3.47	2.92	25.34
Kubusie	122	20	32 35	27 29	2,400	3.13	3.11	2.70	1.68	.78	.60	.44	1.04	1.33	2.20	2.30	2.60	21.90
Kei Road	123	21	32 44	27 33	2,330	3.60	4.19	3.91	2.52	1.38	.85	.84	1.42	2.06	3.30	3.23	3.57	30.87
Fort Jackson	124	20	32 56	27 42	1,110	2.58	2.43	2.69	2.35	1.49	1.09	.83	1.67	2.19	2.75	2.92	2.94	25.93
East London	125	22	32 2	27 55	20	2.29	2.16	2.65	2.30	1.88	1.03	1.13	1.82	1.98	2.42	2.66	2.11	2?.43
Average						3.46	3.30	3.53	2.33	1.53	.93	.97	1.44	2.00	2.81	3.26	3.18	28.74
XI. North-East.—																		
Venterstadt	126	18	30 47	25 47	4,135	2.66	3.33	3.28	2.03	1.47	1.12	.55	.79	.68	1.54	1.49	2.44	21.38
Burghersdorp	127	22	31 2	26 19	4,500	2.58	3.34	3.45	1.80	1.01	.61	.57	.96	.77	1.49	1.65	2.37	20.60
Ellesmere	128	18	30 42	26 20	4,400	2.63	3.19	3.23	1.75	.88	.66	.42	.88	.79	1.31	1.47	2.64	19.85
Cyphergat	129	16	31 27	26 25	5,150	2.94	3.72	3.32	1.93	1.06	1.05	.78	.85	.95	1.65	2.04	3.13	23.42
Thibet Park	130	17	32 10	26 27	4,200	3.17	3.08	3.37	1.64	.87	.55	.59	.96	.85	1.72	1.91	2.84	21.55
Sterkstroom	131	16	31 33	26 33	4,430	3.28	3.64	3.51	1.61	.68	.50	.65	.77	.92	1.47	2.27	3.20	22.50
Aliwal North	132	22	30 41	26 40	4,330	3.65	4.07	4.03	2.23	1.15	.68	.54	1.01	1.03	1.60	1.98	3.29	25.27
Buffelsfontein	133	17	31 22	26 40	6,000	3.34	3.57	3.62	1.99	.97	.71	.65	1.11	.89	1.58	2.53	2.96	23.92
Jamestown	134	22	31 7	26 47	5,000	3.50	3.50	3.53	1.81	1.02	.71	.59	1.24	.99	1.57	1.97	2.53	22.96
Queenstown	135	22	31 54	26 52	3,500	3.93	4.01	3.56	1.71	.90	.49	.71	.90	1.01	1.67	2.56	3.28	24.53
Dordrecht	136	22	31 22	27 2	5,500	3.81	3.81	3.52	1.70	1.01	.54	.58	1.08	1.11	1.83	2.68	3.09	24.76
Tylden	137	20	32 7	27 5	2,900	3.59	2.78	2.81	1.38	.48	.36	.61	.75	.87	1.52	2.20	2.39	19.74
Herschel	138	19	30 36	27 9	5,100	4.78	3.75	4.28	2.83	1.05	.78	.51	1.17	1.03	1.96	2.24	3.57	27.95
Lady Frere	139	17	31 4	27 13	3,400	4.43	4.46	4.24	1.57	.55	.44	.71	1.02	1.17	1.77	2.89	3.80	27.05
Barkly East	140	17	30 58	27 35	5,830	4.25	3.87	3.65	2.23	1.03	.63	.65	1.45	1.11	1.65	2.30	3.49	26.31
Average						3.50	3.61	3.56	1.88	.94	.66	.61	1.00	.94	1.62	2.13	3.00	23.45
XII Kaffraria.—			° '	° '		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	inches
Main	141	14	31 55	27 59	3,010	3.83	2.31	4.20	1.88	.57	.42	.83	1.09	1.67	2.07	3.06	3.65	26.59
Umtata	142	19	31 35	28 46	2,400	3.44	3.21	3.40	1.94	1.12	.52	.75	.96	1.63	2.50	2.82	3.17	25.48
Kokstad	143	18	30 33	29 26	4,285	4.68	3.61	3.48	1.55	1.00	.52	.21	.80	1.32	2.09	3.48	4.35	27.10
Umzimkulu	144	17	30 15	29 56	2,500	4.13	3.81	3.40	1.77	.85	.42	.29	.86	1.58	2.49	3.73	4.43	27.77
Average						4.02	3.49	3.62	1.78	.89	.47	.52	.93	1.55	2.29	3.27	3.90	26.73
XIII. Basutoland																		
Maseru	145	11	29 17	27 30	5,065	5.75	4.38	4.85	2.24	1.04	1.04	.73	.84	1.33	2.79	3.53	3.16	31.88
Moyeni	146	14	30 23	27 45	6,000	6.03	4.27	5.56	3.22	1.56	.90	.67	1.63	1.17	2.93	3.45	5.36	36.75
Leribe	147	12	28 54	28 12	5,210	6.76	3.80	4.48	2.17	1.02	.74	.60	1.15	1.00	2.63	2.87	4.77	32.00
Average						6.18	4.15	4.96	2.54	1.21	.89	.67	1.21	1.17	2.78	3.29	4.50	33.54
XIV Orange River Colony:—																		
Jacobsdal	148	15	29 6	24 49	3,200	3.10	3.12	3.58	1.86	1.31	.66	.28	.43	.58	1.09	1.85	2.45	20.32
Philippolis	149	16	30 13	25 18	4,700	3.28	3.40	3.45	1.71	1.13	.73	.32	.48	.50	1.07	1.64	1.70	19.41
Bethulie	150	16	30 27	25 19	4,290	3.20	3.36	3.37	1.57	.82	.72	.44	.71	.74	1.41	1.47	3.05	20.86
Bloemfontein	151	20	29 7	26 30	4,510	3.81	3.68	3.67	1.99	1.12	.52	.37	.60	.71	1.82	2.22	2.86	23.37
Smithfield	152	15	30 10	26 31	4,400	4.25	3.50	3.17	2.14	1.06	.56	.54	1.03	.82	1.23	1.59	2.84	22.73
Kroonstad	153	22	27 38	27 17	4,500	4.73	3.56	3.75	1.88	.95	.29	.26	.55	.87	2.04	3.46	2.83	25.18
Ladybrand	154	15	29 8	27 31	5,000	5.74	4.85	4.07	2.69	1.21	.68	.69	.99	1.37	2.38	3.55	3.38	31.60
Average						4.02	3.64	3.58	1.98	1.09	.59	.41	.68	.80	1.58	2.25	2.72	23.35
XV. Natal:—																		
Estcourt	155	8	29 1	29 52	?	4.36	4.10	3.86	1.76	.43	.36	.23	.64	.82	2.58	3.16	5.41	27.71
Richmond	156	8	29 51	30 17	?	7.04	4.96	5.06	2.64	1.12	.67	.20	1.32	1.93	3.21	4.20	7.42	39.77
Maritzburg	157	13	29 35	30 23	?	5.62	3.28	4.65	1.74	.83	.31	.16	1.14	1.31	2.70	3.97	5.43	31.14
Greytown	158	8	29 3	30 37	?	5.95	4.53	4.82	1.56	.93	.42	.18	1.07	1.35	3.57	4.96	6.03	35.38
Durban	159	22	29 51	31 0	260	4.60	4.51	4.55	3.04	2.02	.76	.77	1.95	3.73	4.94	4.42	4.51	39.80
Stanger	160	10	29 20	31 19	?	5.25	2.88	5.68	2.48	1.67	1.09	.78	1.42	3.64	5.27	5.37	5.53	41.06
Average						5.47	4.04	4.77	2.20	1.17	.60	.39	1.26	2.13	3.71	4.35	5.72	35.81

se of Cloud at S

	Jul.	Aug.	Sep.	
	%	%	%	
	54	53	51	
	54	53	52	
	33	37	36	
	41	42	36	
	59	59	61	
	38	41	50	
	27	31	39	
	37	39	47	
	42	44	43	
	33	34	40	
	20	29	31	
	26	30	41	
	23	25	27	
	20	17	20	
	29	25	29	
	22	24	29	
	20	20	24	
	22	22	23	
	18	20	20	
	28	28	45	
	26	33	39	
	26	30	41	
	25	27	38	
	34	39	50	
	31	37	47	
	23	30	31	
	24	32	37	
	27	38	49	
	19	21	21	
	16	21	17	
	25	36	50	

Table 26. Constants in the Sine Series for the Annual Curves of Rainfall — South Africa

Station	V_1	V_2	V_3	u_1	u_2	u_3	u_4	u_5	u_6
I	276.7	186.0	77.6	42.4	86.2	19.5	10.9	16.7	8.8
II.	239.9	14.5	92.4	119.3	29.1	23.8	7.3	11.9	14.6
III.	242.0	207.8	97.6	6.4	11.2	11.8	7.6	16.0	19.7
III.N	329.2	24.1.0	12.0.1	10.7	25.6	09.6	4.6	12.0	8.6
III E	19.0	26.3.8	114.8	15.8	26.7	15.8	7.0	12.3	7.4
III W	2.5	20.7.7	7.3	19.1	19.8	09.7	2.0	20.7	6.1
IV. S	32.0	27.4.9	20.9.8	11.6.9	15.9	09.2	1.6.7	15.7	7.1
IV. N	19.3	27.6.8	7.6.0	12.1	20.8	13.7	12.2	19.5	11.8
V. E.	61.1	33.1.8	24.1.8	6.1.1	13.4	05.0	6.4.2	17.1	6.4
V. W.	77.1	13.2.0	23.0.5	7.8.6	20.8	11.2	7.9.2	19.2	9.8
VIII. N.	44.1	23.1.5	21.3.1	14.7	18.7	10.7	8.6.7	21.1	11.0
VIII. E.	67.6	28.7	23.0	9.6	19.8	12.6	09.9	7.6.3	20.6
IX. N	84.8	21.2.3	23.9.9	10.2.1	19.9	10.3	8.2.4	20.6	20.1
IX. S.	47.9	18.2.2	19.6.1	20.1	24.1	18.3	9.8.1	19.1	12.1
X.	98.5	21.3.3	24.2.0	1.2.5.8	32.2	16.2	8.7.3	17.3.6	7.9
XI.	79.2	23.9	23.6.3	17.3.6	40.4	16.2	7.8.6	20.7	9.3
XII.	98.8	11.1	36.4	11.4.5	19.2	16.3	8.1.8	8.2	7.3
XIII	98.5	45.1	20.5.2	11.7.0	07.2	8.1.8	11.2	2.1.6	
XIV.	77.1	24.5	33.1.0	1.0.2	34.7	12.6	8.3.7	17.5	6.4
XV.	10.5	23.0.4	12.9.8	5.4.7.8	11.2	17.6	8.3.6	3.8	5.9

Table 27. Contemporaneous Variation of Rainfall at Durban and Kimberley. Showing the number of Months having a Rainfall above or below the respective Monthly Means in 26 years.

	Durban	—	+	Kimberley	—	+
Jan	9	4	9	6	14	16
Feb	5	4	8	6	14	16
Mar	9	6	4	7	16	13
Apr	9	4	7	7	15	15
May	6	5	9	6	12	15
Jun	13	2	7	8	21	16
Jul	14	4	3	5	19	17
Aug	12	4	6	4	16	18
Sep	15	5	4	2	17	15
Oct	10	7	4	5	15	14
Nov	10	4	5	7	17	15
Dec	13	4	4	7	20	15
	126	53	63	70	196	189

Table 28. Showing the Mean Monthly and Annual Percentage of Cloud at Selected Stations in South Africa

Section	Stations	No. of Yrs.	No. of Obs.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
				%	%	%	%	%	%	%	%	%	%	%	%	%
Section I.	Observatory,	1	18	31	29	36	49	64	64	64	53	51	42	45	38	46
"	Somerset East	5	20	36	32	37	47	52	52	54	51	52	42	41	39	46
" II.	Worcester	14	17	28	31	33	40	42	37	33	32	36	27	32	28	34
"	Clanwilliam	24	19	20	20	23	34	42	42	41	42	36	26	29	25	33
" IV. N.	Cape Lighthouse	28	31	54	54	58	64	60	61	59	59	61	61	61	59	62
"	Mossel Bay	30	22	51	56	54	51	44	41	38	41	50	49	50	47	48
"	Storms River	24	9	36	39	36	32	30	28	27	31	39	43	41	41	35
"	Cape St. Francis	26	19	48	51	48	47	43	40	37	39	43	51	48	44	43
"	Port Elizabeth	40	22	43	46	44	46	43	42	44	43	46	46	46	44	44
" V. W.	Uniondale	18	11	34	34	37	42	40	37	33	34	40	42	37	35	37
" VII.	Graaff Reinet	41	19	31	36	37	37	38	36	30	29	31	32	29	30	33
"	Somerset East	68	19	46	51	49	46	36	30	36	40	48	47	44	41	43
" VIII. N.	Sutherland	32	8	17	14	18	21	28	29	31	28	27	28	17	13	22
"	Magaresberg Canal	38	8	16	21	19	27	24	24	20	17	20	26	20	18	21
"	Beaufort West	36	13	24	25	31	36	37	34	29	28	29	32	31	28	30
" VIII. E.	Graham	56	18	38	32	32	25	21	22	24	29	27	27	28	28	28
"	Standerton	17	14	36	47	51	47	42	40	40	36	29	29	31	28	35
" IX. E.	Hopetown	37	8	31	32	34	29	26	22	22	22	23	32	27	29	27
"	Kimberley	39	22	29	33	32	27	23	17	18	20	20	27	24	25	25
" X.	Bedford	10	10	51	53	47	47	42	41	40	43	47	47	47	46	46
"	Cradock	10.5	17	45	49	50	47	38	29	26	33	29	48	54	46	43
"	Fordvale	11.0	19	48	48	44	43	36	28	26	30	41	46	48	43	40
"	Kuyp Hellenstroom	11.9	20	43	48	42	38	29	25	24	27	38	42	47	42	37
"	Stellenbosch	14.0	17	29	40	37	37	42	38	36	34	30	40	39	40	37
"	Port Nolloth	15.5	21	21	24	20	43	35	33	31	27	43	38	34	43	32
" XI.	Alma Road	13.2	22	27	27	26	36	32	29	25	30	31	36	35	31	33
"	Queenstown	13.2	20	43	44	46	40	33	27	26	32	37	43	39	37	37
" XII.	Pondvale	11.2	17	41	41	43	44	36	30	27	28	29	35	38	36	34
" XIII.	Philippolis	14.9	8	23	20	23	34	29	27	19	21	21	26	26	25	23
"	Standerton	15.1	14	27	34	36	45	47	47	46	41	37	29	27	30	36
" XV.	Durban	18.9	18	58	56	53	49	40	41	45	46	50	62	60	60	61

Table 29. Some Comparative Constants in the Sine Series for the Annual Curves of Cloud and Rainfall in South Africa

Station	V_1	V_2	V_3	u_1	u_2	u_3
1. Cloud						
Durban	119.0	10.2.2	3.6.0	16.8.6	5.8.7	1.0.0
Capetown	16.3	10.4.6	7.6.0	9.7.1	10.3.4	10.8
Bethlehem	10.4	13.9.8	3.1.0.0	5.1.6.4	10.8.5	1.3.3
Maritzburg	12.8	5.2.3.2	2.5.2.2	6.0.3.3	9.0.0.1	1.1.6.9
Swaziland	22.4	9.4.3.7	1.4.6.3	10.0.1.6	3.9.0.6	1.0.1
Aliwal North	7.4	0.4.0.3	5.0.5	3.9.6.1	2.2.1.9	1.2.3.4
Kimberley	7.1	4.2.1.7	0.2.3.8	2.4.2.7	2.7.2.4	6.9.8
Bedfordview	14.2	9.4.7.7	8.1.0.7	1.2.6.1	2.2.6.3	1.2.6.9
Clanwilliam	16.2	3.2.3.8	1.1.1.0	1.1.3.2	4.7.2.2	7.7.2
2. Rainfall						
Durban	109.5	22.1.6	10.7.3	1.9.2.5	9.1.2	1.7.4
Capetown	10.0.6	2.7.9.1	2.0.5.1	8.2.5	4.1.0	1.1.4
Port Elizabeth	21.9.7	2.1.4.1	1.1.6.3	3.3.4	3.1.8.	2.7.4
Maritzburg	3.2.3.1	2.7.7.5	1.6.2.3	1.8.3	4.9.7	1.3.3
Somerset	2.3.5.8	1.6.4.4	2.2.1	1.9.2.3	3.5.8	1.3.
Aliwal North	7.4.6	1.6.3	2.6.0.1	1.7.3	4.2.5	1.2.4
Kimberley	7.3.8	1.5.8.6	2.4.7.3	1.1.8.0	2.4.0	1.5.8
Bedfordview	13.8.5	1.4.7.0	2.3.8.1	9.0.0	1.9.1	1.2.2
Clanwilliam	2.1.6.0	1.7.2.1	1.6.7.3	8.7.9	1.3.1	1.7.5
Adelaide, S. Aus.	2.8.3.2	1.5.6.4	1.2.6.2	1.0.8.5	2.4.3	1.1.4.1
Albany, Georgia	7.7.8	6.2.2	2.1.9	7.1.2	2.8.3	2.8.0
Cordoba, Argen.	1.9.4.7	1.5.8.0	2.4.9.0	2.1.8.7	1.2.0.0	3.7.8

Table 30. Showing the Frequency and Daily Average Fall of Rain corresponding to different Wind-directions at Durban and Kimberley.

	Durban		Kimberley	
	Days.	Inches.	Days.	Inches.
N.	21	1.32	64	1.49
NE.	21	0.56	50	1.02
E.	10	1.21	20	0.6
SE.	33	1.33	12	0.7
S.	71	1.11	6	1.12
SW.	119	0.10	2	1.0
W.	25	1.08	2	0.3
NW.	12	0.90	25	1.02
Calm.	33	1.09		

FACTORIZABLE CONTINUANTS.

By Thomas Muir, LL.D.

(Read December, 1903.)

1. The first to note the existence of a continuant resolvable into linear factors appears to have been Sylvester,* the continuant in question having for the elements of its main diagonal a constant quantity, for the elements of one minor diagonal the integers 1, 2, 3, ... in order, and for the elements of the other minor diagonal the same integers in reverse order: for example

$$\begin{vmatrix} a & 1 & . & . \\ 3 & a & 2 & . \\ . & 2 & a & 3 \\ . & . & 1 & a \end{vmatrix} = (a^2 - 1^2)(a^2 - 3^2).$$

The next was Painvin,† whose continuant had not only the elements of its minor diagonals in equidifferent progression, but those of its main diagonal as well: for example

$$\begin{vmatrix} a & b & . & . \\ 3(b-1) & a-1 & 2b & . \\ . & 2(b-1) & a-2 & 3b \\ . & . & b-1 & a-3 \end{vmatrix} = \begin{cases} (a+3b-3)(a+b-2) \\ (a-b-1)(a-3b), \end{cases}$$

—an identity which, though involving an additional variable, does not include the identity preceding it.

The initial object of the present note is to establish a theorem much more general than either and including both. This done there is then added one or two allied propositions of greater analytical interest.

2. *The* n*-line continuant whose right-hand minor diagonal is* b, $2b$, $3b$, ..., *whose left-hand minor diagonal reversed is* $-c$, $-2c$,

* [Sylvester, J. J.] Théorème sur les déterminants de M. Sylvester.—*Nouv. Ann. de Math.*, xiii., p. 305 (Aug., 1854).

† Painvin, [L.] Sur un certain système d'équations linéaires.—*Journ. de Liouville*, 2e sér., iii., pp. 41–46.

$-3c$; ..., *and whose main diagonal is* a, $a-b-c$, $a-2b-2c$, ..., *is equal to*

$$(a-\overline{n-1}\,.\,b)\,(a-\overline{n-2}\,.\,b-c)\,(a-\overline{n-3}\,.\,b-2c)\,\ldots\ldots\,(a-\overline{n-1}\,.\,c).$$

By way of illustrative proof let us take the case where $n=5$, viz.,

$$\begin{vmatrix} a & b & . & . & . \\ -4c & a-b-c & 2b & . & . \\ . & -3c & a-2b-2c & 3b & . \\ . & . & -2c & a-3b-3c & 4b \\ . & . & . & -c & a-4b-4c \end{vmatrix}.$$

Performing the operation

$$\text{row}_1 + \text{row}_2 + \text{row}_3 + \text{row}_4 + \text{row}_5,$$

removing the factor $a-4c$ and lowering the order of the determinant we have

$$(a-4c)\begin{vmatrix} a-b+3c & 2b+4c & 4c & 4c \\ -3c & a-2b-2c & 3b & . \\ . & -2c & a-3b-3c & 4b \\ . & . & -c & a-3b-4c \end{vmatrix}.$$

Performing on this determinant the operation

$$\text{row}_1 + 2\,\text{row}_2 + 3\,\text{row}_3 + 4\,\text{row}_4$$

we obtain

$$(a-b-3c)\begin{vmatrix} 1 & 2 & 3 & 4 \\ -3c & a-2b-2c & 3b & . \\ . & -2c & a-3b-3c & 4b \\ . & . & -c & a-4b-4c \end{vmatrix}$$

the determinant factor of which reduces to

$$\begin{vmatrix} a-2b+4c & 3b+9c & 12c \\ -2c & a-3b-3c & 4b \\ . & -c & a-4b-4c \end{vmatrix}.$$

On this we now perform the operation

$$\text{row}_1 + 3\,\text{row}_2 + 6\,\text{row}_3$$

obtaining

$$(a-2b-2c)\begin{vmatrix} 1 & 3 & 6 \\ -2c & a-3b-3c & 4b \\ . & -c & a-4b-4c \end{vmatrix}$$

the determinant in which reduces to

$$\begin{vmatrix} a-3b+3c & 4b+12c \\ -c & a-4b-4c \end{vmatrix}.$$

Finally the operation

$$\text{row}_1 + 4\ \text{row}_2$$

enables us to remove the factor $a-3b-c$ and to disclose the final factor $a-4b$. The result thus is

$$(a-4c)\,(a-3c-b)\,(a-2c-2b)\,(a-c-3b)\,(a-4b).$$

3. It is important to take notice of the multiples in the successive row-operations, especially as they appear when placed in the form

$$\begin{array}{ccccc} 1 & 1 & 1 & 1 & 1 \\ 1 & 2 & 3 & 4 & \\ 1 & 3 & 6 & & \\ 1 & 4 & & & \\ 1 & & & & \end{array}$$

—a form resembling what used to be known as "Pascal's triangle." In the second place it should be noted that *the sum of the factors appearing in the final result is the same as the sum of the elements of the main diagonal of the continuant;* the fact being, indeed, that if from the elements of the main diagonal we remove the terms in b, thus obtaining

$$a,\ a-c,\ a-2c,\ a-3c,\ a-4c,$$

and then in reverse order re-annex the said terms we arrive at the factors. Lastly, note should be taken that before deciding whether a given continuant is of the form of § 2, and therefore resolvable into linear factors, it is necessary to bear in mind that a factor in the place (r, s) may be transferred to the place (s, r) without affecting the value of the continuant.

4. Painvin's result is obtained by putting $c=-b+1$, and Sylvester's by putting $c=-b=1$.

Curiously enough, however, there are more continuants than one which resolve into exactly the same factors as Painvin's; thus for the fourth order we have

$$\begin{vmatrix} a+3b & b & . & . \\ -6 & a+b-1 & 2b & . \\ . & -4 & a-b-2 & 3b \\ . & . & -2 & a-3b-3 \end{vmatrix} = \begin{matrix} (a+3b-3)\,(a+b-2) \\ (a-b-1)\,(a-3b), \end{matrix}$$

so that the continuant here and that instanced in § 1 are identical.

The attempt to establish this identity by transforming the one continuant into the other has led to the following theorem, which, besides effecting a still wider generalisation than that of § 2, places the whole matter on a different and far more interesting footing.

5. *The value of the continuant*

$$\begin{vmatrix} a & b & . & \ldots\ldots & . & . \\ (1-n)c & a-b-c & 2b & \ldots\ldots & . & . \\ . & (2-n)c & a-2b-2c & \ldots\ldots & . & . \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots \\ . & . & . & \ldots\ldots & a-(n-2)(b+c) & (n-1)b \\ . & . & . & \ldots\ldots & -c & a-(n-1)(b+c) \end{vmatrix}$$

given in § 2 *is not altered by adding to its matrix the matrix of the continuant*

$$\begin{vmatrix} (n-1)x & x & . & \ldots\ldots & . & . \\ (1-n)x & (n-3)x & 2x & \ldots\ldots & . & . \\ . & (2-n)x & (n-5)x & \ldots\ldots & . & . \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots \\ . & . & . & \ldots\ldots & -(n-3)x & (n-1)x \\ . & . & . & \ldots\ldots & -x & -(n-1)x \end{vmatrix}.$$

The result of performing on the latter matrix the first of the operations performed in § 2 on the original matrix, viz., the operation

$$\text{row}_1 + \text{row}_2 + \text{row}_3 + \ldots\ldots$$

is to make a row of zeros: it follows, therefore, that this operation performed on the matrix, which is the sum of these two matrices, will lead to exactly the same result as in § 2. The same is the effect of the operation

$$\text{row}_1 + 2\,\text{row}_2 + 3\,\text{row}_3 + \ldots\ldots$$

performed on the determinant of order $n-1$, which appears after the removal of the factor $a-(n-1)b$; and so at every successive stage of the factorization.

6. As an illustration of this theorem let us take the case of the fourth order, viz.,

$$\begin{vmatrix} a+3x & b+x & . & . \\ -3c-3x & a-b-c+x & 2b+2x & . \\ . & -2c-2x & a-2b-2c-x & 3b+3x \\ . & . & -c-x & a-3b-3c-3x \end{vmatrix}.$$

Putting $x = -b$ we have verification that the continuant is resolvable into

$$(a - 3b)\,(a - 2b - c)\,(a - b - 2c)\,(a - 3c).$$

Putting $x = -c$ we have a second verification, the factors being now got in the reverse order.

In the third place, the putting of $x=0$ and $x=b$ brings out the identity of Painvin's continuant and that referred to in § 4: the number of such identities, however, is seen to be infinite.

Lastly, the sum of the diagonal elements being independent of x is the same when $x=0$ as when $x = -b$: there is thus verified the assertion of § 3 regarding the sum of the factors in the result.

DEVELOPMENTS OF A PFAFFIAN.

By Thomas Muir, LL.D.

(Read December, 1903.)

1. The *fundamental* development of a Pfaffian is, of course, that which Jacobi used for the purposes of a *definition*, viz., in umbral notation,

$$\begin{aligned} |123456.| \;=\; & 12\cdot|3456| \;-\; 13\cdot|2456| \;+\; 14\cdot|2356| \\ & -\; 15\cdot|2346| \;+\; 16\cdot|2345|, \end{aligned}$$

or, more concretely,

$$\begin{aligned} \begin{vmatrix} a_2 & a_3 & a_4 & a_5 & a_6 \\ & b_3 & b_4 & b_5 & b_6 \\ & & c_4 & c_5 & c_6 \\ & & & d_5 & d_6 \\ & & & & e_6 \end{vmatrix} \;=\; & a_2\cdot\begin{vmatrix} c_4 & c_5 & c_6 \\ & d_5 & d_6 \\ & & e_6 \end{vmatrix} \;-\; a_3\cdot\begin{vmatrix} b_4 & b_5 & b_6 \\ & d_5 & d_6 \\ & & e_6 \end{vmatrix} \;+\; a_4\cdot\begin{vmatrix} b_3 & b_5 & b_6 \\ & c_5 & c_6 \\ & & e_6 \end{vmatrix} \\ & -\; a_5\cdot\begin{vmatrix} b_3 & b_4 & b_6 \\ & c_4 & c_6 \\ & & d_6 \end{vmatrix} \;+\; a_6\cdot\begin{vmatrix} b_3 & b_4 & b_5 \\ & c_4 & c_5 \\ & & d_5 \end{vmatrix}, \end{aligned}$$

the fifteen terms of the development of the Pfaffian of the third degree being got in five sets of three terms each. The analogous development of a determinant, it may be remembered, viz.,

$$|a_1b_2c_3d_4| \;=\; a_1|b_2c_3d_4| \;-\; a_2|b_1c_3d_4| \;+\; a_3|b_1c_2d_4| \;-\; a_4|b_1c_2d_3$$

has also been used for the purposes of a definition, the first to do so being Vandermonde (1771).

2. In the second place, since

$$\begin{vmatrix} a_2 & a_3 & a_4 & a_5 & a_6 \\ & b_3 & b_4 & b_5 & b_6 \\ & & c_4 & c_5 & c_6 \\ & & & d_5 & d_6 \\ & & & & e_6 \end{vmatrix} = a_2\begin{vmatrix} c_4 & c_5 & c_6 \\ & d_5 & d_6 \\ & & e_6 \end{vmatrix} + \begin{vmatrix} \cdot & a_3 & a_4 & a_5 & a_6 \\ & b_3 & b_4 & b_5 & b_6 \\ & & c_4 & c_5 & c_6 \\ & & & d_5 & d_6 \\ & & & & e_6 \end{vmatrix},$$

and since the Pfaffian on the extreme right can be expressed as an

aggregate of products, each of which has for its first factor one of the determinants of the set

$$\left\| \begin{matrix} a_3 & a_4 & a_5 & a_6 \\ b_3 & b_4 & b_5 & b_6 \end{matrix} \right\|,$$

and for its second factor one of the remaining elements of the Pfaffian,* we obtain

$$\left| \begin{matrix} a_2 & a_3 & a_4 & a_5 & a_6 \\ & b_3 & b_4 & b_5 & b_6 \\ & & \cdots\cdots\cdots & & \\ & & & & e_6 \end{matrix} \right| = a_2 \left| \begin{matrix} c_4 & c_5 & c_6 \\ & d_5 & d_6 \\ & & e_6 \end{matrix} \right| - |\, a_3\, b_4 |.e_6 + |\, a_3\, b_5 |.d_6 - |\, a_3\, b_6 |.d_5 - |\, a_4\, b_5 |.c_6 + |\, a_4\, b_6 |.c_5 - |\, a_5\, b_6 |.c_4,$$

the fifteen terms of the development being now got in one set of three and six sets of two. (E_1)

3. In the third place, since neither a_3 nor b_3 can occur in the same term with a_2, we have from the second line of § 2

$$\left| \begin{matrix} a_2 & a_3 & a_4 & a_5 & a_6 \\ & b_3 & b_4 & b_5 & b_6 \\ & & \cdots\cdots\cdots & & \\ & & & & e_6 \end{matrix} \right| = a_2 \left| \begin{matrix} c_4 & c_5 & c_6 \\ & d_5 & d_6 \\ & & e_6 \end{matrix} \right| - a_3 \left| \begin{matrix} b_4 & b_5 & b_6 \\ & d_5 & d_6 \\ & & e_6 \end{matrix} \right| + \left| \begin{matrix} . & . & a_4 & a_5 & a_6 \\ & . & b_4 & b_5 & b_6 \\ & & c_4 & c_5 & c_6 \\ & & & d_5 & d_6 \\ & & & & e_6 \end{matrix} \right| + b_3 \left| \begin{matrix} a_4 & a_5 & a_6 \\ & d_5 & d_6 \\ & & e_6 \end{matrix} \right|,$$

or, if we use A_2, A_3, B_3 for the complementary minors of a_2, a_3, b_3, and put for the Pfaffian on the extreme right its equivalent the determinant $-\,|\, a_4\, b_5\, c_6 \,|$, there results

$$\left| \begin{matrix} a_2 & a_3 & a_4 & a_5 & a_6 \\ & b_3 & b_4 & b_5 & b_6 \\ & & \cdots\cdots\cdots & & \\ & & & & e_6 \end{matrix} \right| = a_2A_2 - a_3A_3 + b_3B_3 - |\, a_4\, b_5\, c_6 \,|. \qquad (\lambda_2)$$

This, however, by reason of the low degree of the Pfaffian on the left, is a defective illustration of the form of development now reached. Taking, instead, the Pfaffian of next higher degree we have

$$\left| \begin{matrix} a_2 & a_3 & a_4 & \ldots & a_8 \\ & b_3 & b_4 & \ldots & b_8 \\ & & \cdots\cdots\cdots & & \\ & & & & g_8 \end{matrix} \right| = a_2A_2 - a_3A_3 + b_3B_3 + \left| \begin{matrix} . & . & a_4 & a_5 & \ldots & a_8 \\ & . & b_4 & b_5 & \ldots & b_8 \\ & & c_4 & c_5 & \ldots & c_8 \\ & & & \cdots\cdots\cdots & & \\ & & & & & g_8 \end{matrix} \right|,$$

$$= a_2A_2 - a_3A_3 + b_3B_3 - \Sigma(|\, a_4b_5c_6 \,|.g_8),$$

* See *Trans. Roy. Soc. Edinburgh*, xl., pp. 49–58.

the 105 terms of the Pfaffian being got in 3 sets of 15, and 10 sets of 6 each. (E_2)

4. We may pursue the process further and obtain a fourth development of a like character, but a drawback then attaches to the result, the fact being that it is impossible now to say that the Pfaffian

$$\begin{vmatrix} . & . & a_4 & a_5 & \dots & a_8 \\ & . & b_4 & b_5 & \dots & b_8 \\ & & c_4 & c_5 & \dots & c_8 \\ & & & d_5 & \dots & d_8 \\ & & & & \dots & \dots \\ & & & & & g_8 \end{vmatrix}$$

with its three vacant places is equal to

$$\begin{array}{r} a_4\mathrm{A}_4 + \\ -\, b_4\mathrm{B}_4 \\ +\, c_4\mathrm{C}_4 \end{array} \begin{vmatrix} . & . & . & a_5 & a_6 & a_7 & a_8 \\ & . & . & b_5 & b_6 & b_7 & b_8 \\ & & . & c_5 & c_6 & c_7 & c_8 \\ & & & d_5 & d_6 & d_7 & d_8 \\ & & & & & \dots & \dots \\ & & & & & & g_8 \end{vmatrix},$$

the cofactors of a_4, $-b_4$, c_4 in the said Pfaffian being not A_4, B_4, C_4, but

$$\begin{vmatrix} . & b_5 & b_6 & b_7 & b_8 \\ & c_5 & c_6 & c_7 & c_8 \\ & & e_6 & e_7 & e_8 \\ & & & f_7 & f_8 \\ & & & & g_8 \end{vmatrix}, \quad \begin{vmatrix} . & a_5 & a_6 & a_7 & a_8 \\ & c_5 & c_6 & c_7 & c_8 \\ & & e_6 & e_7 & e_8 \\ & & & f_7 & f_8 \\ & & & & g_8 \end{vmatrix}, \quad \begin{vmatrix} . & a_5 & a_6 & a_7 & a_8 \\ & b_5 & b_6 & b_7 & b_8 \\ & & e_6 & e_7 & e_8 \\ & & & f_7 & f_8 \\ & & & & g_8 \end{vmatrix}.$$

If, therefore, we insist on retaining $a_4\mathrm{A}_4 - b_4\mathrm{B}_4 + c_4\mathrm{C}_4$, we shall be repeating 9 terms already included in $a_2\mathrm{A}_2 - a_3\mathrm{A}_3 + b_3\mathrm{B}_3$, and must rectify the error by bringing in the product

$$- \begin{vmatrix} a_2 & a_3 & a_4 \\ & b_3 & b_4 \\ & & c_4 \end{vmatrix} . \begin{vmatrix} e_6 & e_7 & e_8 \\ & f_7 & f_8 \\ & & g_8 \end{vmatrix},$$

the result being

$$\begin{vmatrix} a_2 & a_3 & a_4 & a_5 & \dots & a_8 \\ & b_3 & b_4 & b_5 & \dots & b_8 \\ & & c_4 & c_5 & \dots & c_8 \\ & & & \dots & \dots & \dots \\ & & & & & g_8 \end{vmatrix} = a_2\mathrm{A}_2 - a_3\mathrm{A}_3 + a_4\mathrm{A}_4 - \begin{vmatrix} a_2 & a_3 & a_4 \\ & b_3 & b_4 \\ & & c_4 \end{vmatrix} . \begin{vmatrix} e_6 & e_7 & e_8 \\ & f_7 & f_8 \\ & & g_8 \end{vmatrix}$$
$$+ b_3\mathrm{B}_3 - b_4\mathrm{B}_4 + c_4\mathrm{C}_4 + \begin{vmatrix} a_5 & b_6 & c_7 & d_8 \end{vmatrix}, \qquad (\lambda_3)$$

where, instead of the 105 terms of the proper development, we have 123, viz., 6 sets of 15 each, 1 set of 9, cancelling a previous 9, and 1 set of 24.

5. If with an initial Pfaffian of still higher degree we write the result of the preceding paragraph, *e.g.*,

$$\begin{vmatrix} a_2 & a_3 & a_4 \dots a_{10} \\ & b_3 & b_4 \dots b_{10} \\ & & c_4 \dots c_{10} \\ & & \dots\dots\dots \\ & & i_{10} \end{vmatrix} = a_2A_2 - a_3A_3 + a_4A_4 - \begin{vmatrix} a_2 & a_3 & a_4 \\ & b_3 & b_4 \\ & & c_4 \end{vmatrix} . \begin{vmatrix} e_6 & e_7 & e_8 & e_9 & e_{10} \\ & f_7 & f_8 & f_9 & f_{10} \\ & & \dots\dots\dots \\ & & & & i_{10} \end{vmatrix}$$
$$+ b_3B_3 - b_4B_4$$
$$+ c_4C_4$$
$$+ \begin{vmatrix} . & . & . & a_5 & a_6 & \dots & a_{10} \\ & . & . & b_5 & b_6 & \dots & b_{10} \\ & & . & c_5 & c_6 & \dots & c_{10} \\ & & & d_5 & d_6 & \dots & d_{10} \\ & & & & e_6 & \dots & e_{10} \\ & & & & & \dots\dots\dots \\ & & & & & & i_{10} \end{vmatrix},$$

and then again as an equivalent for the Pfaffian on the extreme right, put

$$\begin{matrix} -a_5A_5 \\ +b_5B_5 \\ -c_5C_5 \\ +d_5D_5 \end{matrix} + \begin{vmatrix} . & . & . & . & a_6 & a_7 & \dots & a_{10} \\ & & . & . & b_6 & b_7 & \dots & b_{10} \\ & & & . & c_6 & c_7 & \dots & c_{10} \\ & & & & d_6 & d_7 & \dots & d_{10} \\ & & & & & e_6 & \dots & e_{10} \\ & & & & & & \dots\dots\dots \\ & & & & & & & i_{10} \end{vmatrix}$$

compensating for this error by inserting

$$\begin{vmatrix} a_2 & a_3 & a_5 \\ & b_3 & b_5 \\ & & c_5 \end{vmatrix} . \text{compl} - \begin{vmatrix} a_2 & a_4 & a_5 \\ & b_4 & b_5 \\ & & d_5 \end{vmatrix} . \text{compl} + \begin{vmatrix} a_3 & a_4 & a_5 \\ & c_4 & c_5 \\ & & d_5 \end{vmatrix} . \text{compl}$$
$$- \begin{vmatrix} b_3 & b_4 & b_5 \\ & c_4 & c_5 \\ & & d_5 \end{vmatrix} . \text{compl},$$

we shall obtain an identity which is of still less value when viewed as giving a development of the given Pfaffian, viz.,

$$\begin{vmatrix} a_2 & a_3 & a_4 \dots a_{10} \\ & b_3 & b_4 \dots b_{10} \\ & & c_4 \dots c_{10} \\ & & \dots\dots\dots \\ & & i_{10} \end{vmatrix} = a_2A_2 - a_3A_3 + a_4A_4 - a_5A_5 - \begin{vmatrix} a_2 & a_3 & a_4 \\ & b_3 & b_4 \\ & & c_4 \end{vmatrix} . \text{compl}$$
$$+ b_3B_3 - b_4B_4 + b_5B_5$$
$$+ c_4C_4 - c_5C_5$$
$$+ d_5D_5$$
$$+ \begin{vmatrix} a_2 & a_3 & a_5 \\ & b_3 & b_5 \\ & & c_5 \end{vmatrix} . \text{compl} - \begin{vmatrix} a_2 & a_4 & a_5 \\ & b_4 & b_5 \\ & & d_4 \end{vmatrix} . \text{compl}$$
$$+ \begin{vmatrix} a_3 & a_4 & a_5 \\ & c_4 & c_5 \\ & & d_5 \end{vmatrix} . \text{compl} - \begin{vmatrix} b_3 & b_4 & b_5 \\ & c_4 & c_5 \\ & & d_5 \end{vmatrix} . \text{compl}$$
$$+ \begin{vmatrix} a_6 & b_7 & c_8 & d_9 & e_{10} \end{vmatrix}, \qquad (\lambda_4)$$

for here, instead of the 945 terms of the proper development, we have 10 sets of 105 terms each, 5 sets of 45 terms each, which merely cancel 225 terms of the preceding sets, and 1 final set of 120.

6. Using, as above, the contraction "compl" to stand for the complementary minor of the determinant or Pfaffian which precedes it,* we may formulate as follows the series of general identities thus reached:—

$$\left|\begin{matrix} a_2 & a_3 & \dots & a_{2n} \\ & b_3 & \dots & b_{2n} \\ & & \dots\dots & \end{matrix}\right| = a_2A_2 - \Sigma\{|\, a_3\ b_4\,|.\text{compl}\}, \qquad (E_1)$$

$$= a_2A_2 - a_3A_3 - \Sigma\{|\, a_4\ b_5\ c_6\,|.\text{compl}\}, \qquad (E_2)$$
$$+ b_3B_3$$

$$= a_2A_2 - a_3A_3 + a_4A_4 - \left|\begin{matrix} a_2 & a_3 & a_4 \\ & b_3 & b_4 \\ & & c_4 \end{matrix}\right|.\text{compl}$$
$$+ b_3B_3 - b_4B_4$$
$$+ c_4C_4$$

$$+ \Sigma\{|\, a_5\ b_6\ c_7\ d_8\,|.\text{compl}\} \qquad (E_3)$$

$$= \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots$$

it being remembered that only the first two identities are unexceptionably effective, giving, as they do, the final development of the Pfaffian without superfluous terms.

It may be noted in passing that the triangular mode of disposing the terms of the first kind on the right is not without advantage, in that it is a help to the formation of the terms of the second and following kinds. Thus in (E_4) having to commence with

$$\begin{matrix} a_2.\text{cof} & + & a_3.\text{cof} & + & a_4.\text{cof} & + & a_5.\text{cof} \\ & + & b_3.\text{cof} & + & b_4.\text{cof} & + & b_5.\text{cof} \\ & & & + & c_4.\text{cof} & + & c_5.\text{cof} \\ & & & & & + & d_5.\text{cof} \end{matrix}$$

it is only necessary to leave out in succession the first, second, ... frame-lines of this quasi-Pfaffian, and we obtain

$$+ \left|\begin{matrix} b_3 & b_4 & b_5 \\ & c_4 & c_5 \\ & & d_5 \end{matrix}\right|.\text{cof} + \left|\begin{matrix} a_3 & a_4 & a_5 \\ & c_4 & c_5 \\ & & d_5 \end{matrix}\right|.\text{cof} + \left|\begin{matrix} a_2 & a_4 & a_5 \\ & b_4 & b_5 \\ & & d_5 \end{matrix}\right|.\text{cof} + \dots;$$

in (E_5), the triangular matrix being larger, it is possible to form from

* If strict uniformity of notation were more important than brevity, such a term as "a_2A_2" would have to be replaced by "a_2 . compl." Perhaps the best uniform notation, however, would be got by using a contraction of the word *cofactor*, say the contraction "cof"; the difficulty of indicating what signs are to be +, and what −, would also then be avoided.

it a Pfaffian of the third order, so that the terms of the second kind just given would be followed by

$$\left| \begin{matrix} a_2 & a_3 & a_4 & a_5 & a_6 \\ & b_3 & b_4 & b_5 & b_6 \\ & & c_4 & c_5 & c_6 \\ & & & d_5 & d_6 \\ & & & & e_6 \end{matrix} \right| . \text{ cof ;}$$

and so on.

It is also worth noting that there is an interesting alternative form which may be substituted for the first three terms in (E_2), (E_3), ..., viz.,

$$\left| \begin{matrix} a_2 & a_3 & a_4 \\ & b_3 & b_4 \\ & & c_4 \end{matrix} \right| .\text{compl} - \left| \begin{matrix} a_2 & a_3 & a_5 \\ & b_3 & b_5 \\ & & c_5 \end{matrix} \right| .\text{compl} + \ \ldots \ - \left| \begin{matrix} a_2 & a_3 & a_{2n} \\ & b_3 & b_{2n} \\ & & c_{2n} \end{matrix} \right| .\text{compl.}$$

7. When the identity (E_1) is applied to a Pfaffian of the 2nd degree, (E_2) to a Pfaffian of the 3rd degree, and so on, the development in each case ends with only one determinant under the sign of summation: that is to say, we have

$$\left| \begin{matrix} a_2 & a_3 & a_4 \\ & b_3 & b_4 \\ & & c_4 \end{matrix} \right| = a_2.c_4 \ - \ \left| \begin{matrix} a_3 & b_4 \end{matrix} \right| \qquad (\lambda_1)$$

and the other special cases marked (λ_2), (λ_3), (λ_4) above, &c. To all except the first two of these there attaches, of course, the blemish attaching to (E_3), (E_4), ... It is greatly magnified, however, if, instead of viewing the λ identities as giving the development of the single Pfaffian on the left, we transform them so as to present an equivalent for the solitary *determinant* on the right.* Not only so, but the blemish then attaches to (λ_1) and (λ_2) also. Thus, taking the case of (λ_2), which then becomes

$$\left| \begin{matrix} a_4 & a_5 & a_6 \\ b_4 & b_5 & b_6 \\ c_4 & c_5 & c_6 \end{matrix} \right| = \left| \begin{matrix} a_2 & a_3 & a_4 & a_5 & a_6 \\ & b_3 & b_4 & b_5 & b_6 \\ & & c_4 & c_5 & c_6 \\ & & & d_5 & d_6 \\ & & & & e_6 \end{matrix} \right| - a_2 \left| \begin{matrix} c_4 & c_5 & c_6 \\ & d_5 & d_6 \\ & & e_6 \end{matrix} \right| + a_3 \left| \begin{matrix} b_4 & b_5 & b_6 \\ & d_5 & d_6 \\ & & e_6 \end{matrix} \right| - b_3 \left| \begin{matrix} a_4 & a_5 & a_6 \\ & d_5 & d_6 \\ & & e_6 \end{matrix} \right| ,$$

* This is the way in which the identities are viewed in a paper by Mr. J. Brill, which has just appeared in the *Proceedings of the London Math. Soc.* (see Vol. I. of Second Series, pp. 103–111). The subject of the paper, it may also be mentioned, might well be overlooked, as the title under which it appears is "On the Minors of a Skew-symmetrical Determinant," whereas the only theorem contained in it is that here (§ 7) illustrated.

we see that to reach the six well-known terms of $| a_4\ b_5\ c_6 |$ we have to handle 1 set of 15 terms followed by 3 sets of 3 terms each, the last 9 terms appearing merely for the purpose of cancelling 9 of the 15 which precede them; furthermore, six variables occur in the development which have nothing to do with the function sought to be developed.

HIGH-LEVEL GRAVELS OF THE CAPE AND THE PROBLEM OF THE KARROO GOLD.

By E. H. L. Schwarz, A.R.C.S., F.G.S.

(Read January 27, 1904.)

Plates II.–V.

The high-level gravels of South Africa have attracted a good deal of attention for some considerable time owing to the peculiar position they occupy. They are found capping the flat-topped hills all over the southern coast-regions of the Colony—at one time as a flinty quartzite, when they have been mistaken for lava-flows; at another as thick beds of gravel- and boulder-beds perched many hundreds of feet above the present levels of the rivers, when they have been mistaken for the Enon Conglomerate, a member of the Uitenhage Series of Jurassic age.

They were first studied by Mr. Rogers and myself along the seaward face of the great coast-ranges, especially in Caledon, Swellendam, and Riversdale, and later, in the extreme east, in Komgha and Kentani. For some time it was not clear whether the gravels here were old sea-beaches, and that the level flats which they must have originally covered were not surf-cut terraces. As a matter of fact the sea is at the present time cutting ledges along the coast which at low tide are exposed and continue the rocky land-surface for a considerable distance out to sea; east of Cape Agulhas, as far as the Pondoland shore, these surf-cut terraces occur repeatedly, and form the home of the oyster, the octopus, the ollycrock, and other sea delicacies. The gravels, however, have more the appearance of river-borne material, and the fine sands that of river-sand, and the question has been practically settled by the discovery of the fruits of *Chara*—a typical fresh-water weed embedded in the hardened sands in Komgha.

Inland the evidences of the gravels were not so abundant, though Mr. Rogers and myself have recorded them as occurring in Ladismith, Oudtshoorn, and Prince Albert. For the whole of the last year I have been working on the watershed between the Gouritz and Gamtoos river-systems, and have found the high-level gravels

enormously developed, or rather, since they must have existed equally all over the other districts in which small vestiges are still retained, where they have been very little disturbed by denudation.

Seeing these gravels, then, in their full development, I have been able to get a better grasp of their meaning and origin, and I propose in the present paper to work out my views in regard to them. I dare say these will need some modification as our knowledge advances, yet I think a useful purpose will be served in drawing under one head an important body of facts.

Stated briefly, my idea is that at no very distant time there was a plain passing all over the southern part of the continent, and far into the Karroo, which was elevated some 1,000 feet above the level of the present rivers—that is to say, on the coast it was 1,000 feet to 2,000 feet above the present sea-level; in the interior mountainous district, Ladismith, Oudtshoorn, and Baviaan's Kloof, it was 3,000 feet and more, and on the Karroo side of the coast-range it was 3,000 feet to 4,000 feet. This plain was formed when the rivers had reached a quiet stage in their denudation—that is, a period when they no longer cut downwards, but had time to meander backwards and forwards and reduce all the country to a more or less dead flat.

When a river has reached this stage, it is said to have reached its base-level of erosion, and the plain is called a peneplain. It usually occurs when the fall of the river is a very gradual one from a long way inland to its debouchment into the sea. It cannot, however, be said that the present rivers of South Africa have such a gentle fall; in fact, it is the steep gradients that cause all the trouble of the droughts by draining away the water so rapidly; as the plain keeps approximately at the same height above these present river-courses, some other cause than a gradual fall is necessary to explain their existence. The other cause is afforded by the mountain chains which the rivers had to traverse; these produced bars across the river channels, which had to be cut down before the river was free to flow to the sea, and hence behind each mountain chain there was an enforced period of base-levelling, so that the plain, instead of being one continuous slope, is cut into a series of steps. I do not offer this explanation from purely theoretical considerations, but, as we shall see later, there are actually plains now being formed in the Long Kloof from exactly such a cause. The plain-formation, however, must have been aided by a condition in the equilibrium of the land unlike that through which we are now passing, which is one of continuous uplift, so that the rivers are constantly cutting downwards. Before this rise, and may be at the time of the plain-formation, there must have been a great sinking, as the shallow sea-bottom which

extends out to the Agulhas Bank was almost certainly at one time dry land, which has now been covered by the sea, and formed a base-levelled plain at some remote period. The level of a plain need not be all reduced to sea-level in order to produce base-levelling, as a stoppage low down in a river-course, whether from its confluence with the ocean or from a bar in its course, reacts very strongly on the denudation of its upper course; it is as if the river when rapidly flowing was to a certain extent rigid. Good instances of this are afforded by dams across the dry rivers of the Karroo: the water is stopped by the dam-wall, and this reacts all along its course up; floods occur far beyond what one would at first sight think possible for the effect of the dam-wall to reach.

The rocks cut by this bevelling process include all the known rock formations in the west of the Colony, except the Recent; Uitenhage Beds are bevelled equally with the Malmesbury clay-slates, so that the plains were subsequent to the mountain-building and to the Jurassic or Lower Cretaceous rock-formations.

These plains are only plains in the centres of their areas; on one side, or on both, the plain rises to the mountains from which the streams flow (Plate X. 1). Ralph Tarr * has applied to the action of rivers when they cut inclined plains like this the term of "bevelling," and by an extension of the term I shall allude to the intra-mountain plains as double bevels. Of such double bevels there are a number of series between Ladismith and Uitenhage, but the effect of them all was to produce wide-open valleys all longitudinally on about the same level. On the north of this area, in the Karroo, there was a single bevel with a wide peneplain extending some way towards the Nieuweveld and Camdeboo, and on the seaward side there was the single bevel forming the Ruggens of Caledon and Swellendam, and the table-topped hills all along the coast.

As the evidence is best in the double-bevelled region, I will begin my description with that. There are two rivers running westwards towards Oudtshoorn, the Kammanassie and the Oliphant's Rivers. The former has had to excavate its bed through the loose sands and conglomerates of the Uitenhage Series (Fig. 1), while the latter has had to work its way through solid Bokkeveld slates; hence the Oliphant's River has stolen a march on the Kammanassie, and has not only been able to clear its bed and lay down wide alluvial flats, but has captured the head-waters of its rival, so that the Kammanassie River no longer reaches the water-parting between the Gouritz and Gamtoos river-systems. The smaller river, however, is much more interesting, as the stream and its side tributaries has simply

* "The Peneplain," *American Geologist*, xxi., 1898.

cut downwards, leaving the old bevel-surface entire except for the cañon-like gorge through which the rivers run. The farms along the main river are divided into two kinds, one lying on the river-level and utilising the narrow strip of alluvium, the other lying in wide open plains some 800 feet above the other. Communication between the two sets of farms can only be made at a few points, and then the road or footpath is extremely precipitous. Above the plains the mountains rise—on one side, the Long Kloof Mountains, and on the north the Kammanassie. The village of Uniondale lies in the low level along the Kammanassie River, on a place where a tributary from the Long Kloof has by some curious chance been added to its catchment area, and the impact of this new increment of water has washed out a comparatively wide opening in the river valley. East

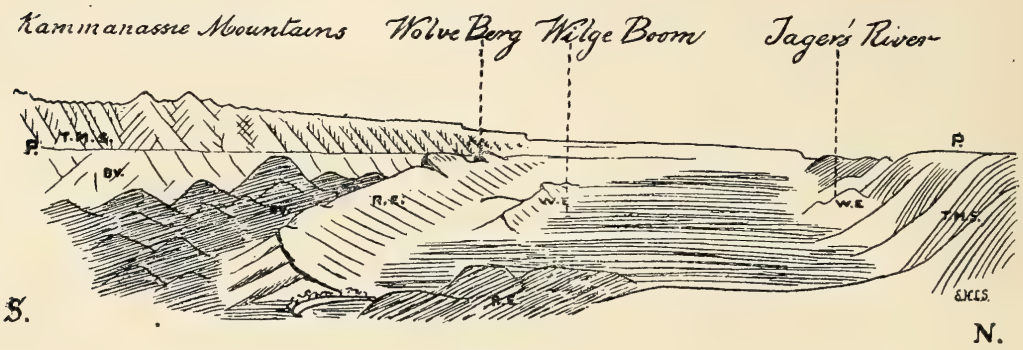


Fig. 1.

P. The High-Level Plateau. **R.E.** Red Enon. **W.E.** White Enon Conglomerate. **BV.** Bokkeveld Beds. **T.M.S.** Table Mountain Sandstone.

The Oliphant's River Valley, showing the fold-basin of Enon Conglomerate and the High-Level Plateau or Bevel.

of Uniondale there is the Uitvlugt Berg, which seems a considerable mountain from the village, but on getting out of the gorge of the Kammanassie River on to the plain it loses a good two-thirds of its height; a shelf belonging to the bevel, and covered with fine gravel, skirts the mountain on the south side, while on the north side there is the high plateau itself, only indented by shallow river courses.

At the eastern end of Uitvlugt the river ends blindly in the plateau, and a bunch of finger-like gorges are cut into it. The gravel cap here is very well exposed and is continuous; in the centre of the double bevel it consists of yellow sand some thirty feet thick. The upper portion of the sand becomes intensely hard, due to the deposition of secondary silica between the sand grains; lower down the rock becomes softer, and near the bottom is loose, clayey sand that can be dug with a spade. The quartzite-like surface cracks up

into blocks, which are rounded and become polished by the sand blown over them. The fort protecting the village of Uniondale is built on a very good example of wind-polished surface-quartzite (Plate X. 2). The rock is an exceedingly good building stone: the harder varieties can be used for foundations, bridge work, &c., while the softer are useful for walling; by choosing the particular hardness varieties can be obtained which take mouldings and chisel work. The softer kinds harden on exposure, and once hard are not subject to rotting like the calcareous sands of the coast, as the cementing material here is silica. It is interesting to notice that, with an abundance of the best building stone in the immediate neighbourhood, the architect of the local Dutch Church, in picking the stone for building the tower, took the Table Mountain Sandstone. The rock in its normal condition is all right, but here it is penetrated with shear-planes, along which white mica is developed; the consequence was that before the roof was in place the tower had to be pulled down. In the gravel at the head of the Kammanassie River, beyond Uitvlugt, there are three distinct zones, which seems to point to the fact that after the first layer of gravel was deposited the river became more obstructed, and a higher layer was laid down, and subsequently a third, which facts accord well with the theory that the obstruction was due to the successive sinking of the land surface.

The formation of the steep-sided gorges that commence at their actual heads, with as great a height of wall as lower down, require some explanation. No springs occur in them, and the erosion works backwards as if an invisible steam-shovel were gnawing out the material. Walther, in his monograph on the Deserts, makes out tha these cul-de-sacs are peculiar to excessively dry regions subjected now and again to tremendous cloud-bursts. Here, however, we have them forming in a well-watered region, and though it is getting to be a desert from the burning of the mountain veld, it was evidently in former ages very much better watered than now. I think the explanation may be got from studying the drainage system. The Oliphant's River has beheaded the Kammanassie River and left the present head in an aimless way out on the flats. To compensate for this loss, the river has got a large supply of water from the Long Kloof, which runs in at Uniondale, some eight miles down stream from the nominal head; the effective head now lying at the summit of the Prince Alfred's Pass. Directly the main river got this increment, it was once again turned into a powerful chisel of erosion, and rapidly deepened its course. The upper portion, though only containing water after rain, was affected by this lowering of the general level of the main valley, and erosion worked backwards by a kind of

under tow, the bottom of the banks being first attacked, instead of the usual gradual scouring all along the gradient.

The basin of the Kammanassie River is divided from the Long Kloof by a range of hills ; looked at from the head of the pass from Uniondale to Avontuur, the gravel-covered level is seen to be almost continued over the dividing ridge, so that when the gravel was formed erosion of the ridge had practically stopped. Since then, owing to the uplift, the rivers have cut vigorously downwards, but those in the Long Kloof seem to have arrived at such a state of equilibrium that the water was actually stagnant. Near Avontuur, for instance, one area is drained by a stream that has crept in from the Kammanassie River on the north ; another contiguous one has been invaded by a river cutting back from the south, and now drains straight into the ocean by the Keurboom's River, while a third drains eastwards to the Kouga. The Long Kloof is a narrow valley of

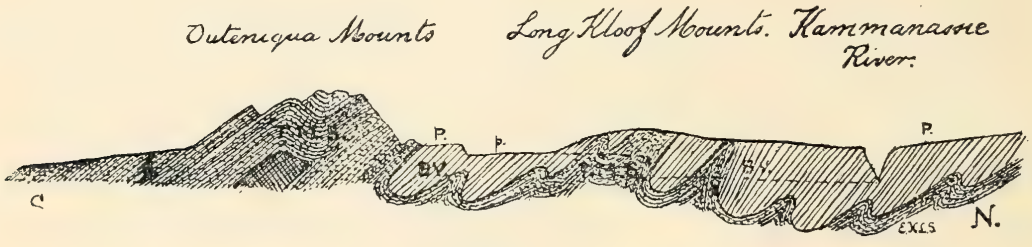


Fig. 2.

Section across the Long Kloof and Kammanassie River valley to show the bevelling (**P.P.**) and the formation of a lower plain of erosion (*p.*) due to the obstruction of the stream marked - - - - by the Table Mountain Sandstone (**T.M.S.**) in he Long Kloof Mountains.

Bokkeveld Beds hedged in with hills of Table Mountain Sandstone, and there seems at first sight no reason why one large river should not drain right away down the valley, as is the case with the Oliphant's River in Clanwilliam, which is similarly encompassed. When, however, we find evidence of a former period of no flow—that is, that the whole of the Long Kloof near Uniondale was converted at the time into a swamp—we can understand how it is the side streams from more vigorous river-systems have had time to eat their way back through the dividing ridges, and steal each what it could from this stagnant region. Directly the drainage of the Long Kloof commenced, the plain that had been formed became eaten into by ravines, and when these spread and spread, the plain with its gravel covering became reduced to mere remnants, and hence we see little table-topped hills, gravel-capped, in many places between Avontuur and the George-Oudtshoorn road. Some of these invading streams,

however, took on more than they could satisfactorily accomplish; for instance, above Commandant's Drift on the Kammanassie, the river of that name has sent a side streamlet that has tapped the Long Kloof east of the farm Molen River (Fig. 2); the water pours out over a fine waterfall into a deep pool, and is carried out in furrows; after the gorge had been first formed, the running water cut down to extremely hard quartzite, which it has only been able to wear away very slowly; hence the drainage area behind the waterfall has remained at a minimum level for a very long time, and has thus been made into a plain of erosion exactly as the higher plain,

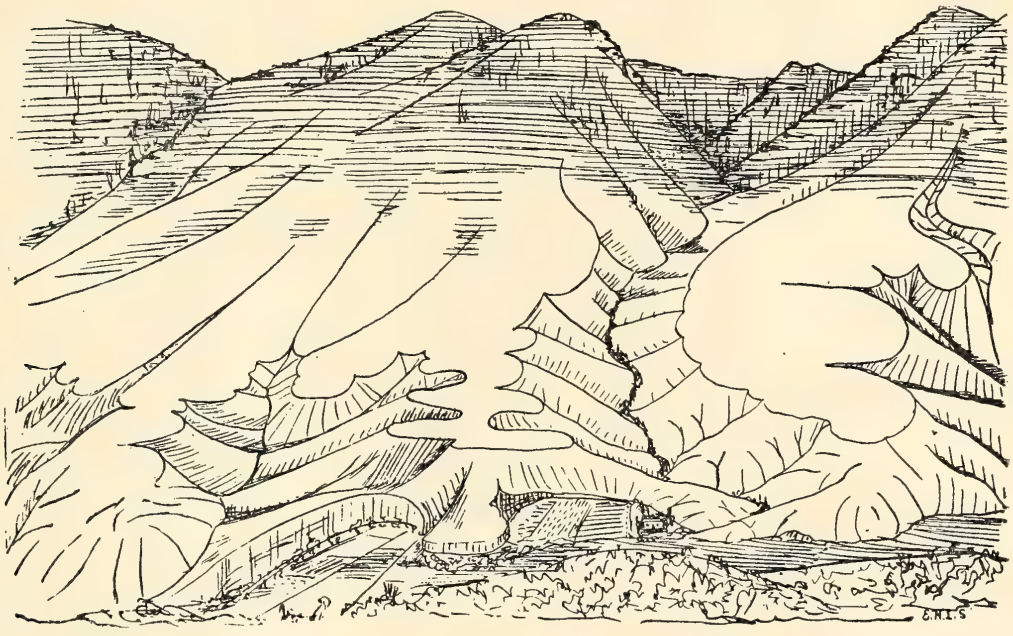


Fig. 3.

Birds'-eye view of the gravel-capped bevel in the Kammanassie Valley opposite Commando Kraal.

of which a few flat-topped hills attest the former existence, was cut down. The Long Kloof, unfortunately, has not yet been geologically surveyed to any great extent, and a good deal more about these river-systems will be learnt when it is done. The gravels in the Kammanassie Valley about Commandant's Drift, and lower down, are coarser than round Uniondale, and are heavily charged with iron (Fig. 3).

In the upper Oliphant's River we have another area where the gravels can be very well seen. Standing on any high point in the rim of the basin one notices a shelf cut in the mountains, which runs uninterruptedly and at exactly the same level all round. It looks as if it were the eroded edge of a lake whose waters had now been

withdrawn, and the occurrences of gravels on the ledge lends additional evidence for this view. But on studying the area further, it will be seen that there are several hills in the centre of the basin which come up just to the level of the ledge and no further, and slowly one gets to recognise that the ledge is but the remnant of a wide high-level plateau which has since been cut into by the natural forces of erosion. Along the south side of the basin, and north of the Kammanassie Mountain, the shelf is still very broad, running out from the mountain a mile or more, and there are only deep and narrow gorges cut into it. The rock out of which the shelfs are cut is mostly Bokkeveld Beds. On the north of the basin, however, the width of the shelf is much less, and the end of the remnants facing the main river are not simple mountain slopes covered with débris, but are true dip-slopes of Table Mountain Sandstone. The dip-slopes are very steep, from 45° to 60°, and on some a small patch of Bokkeveld slates is still adherent, and Enon Conglomerate is also to some extent piled against them, but for the most part they are bare rock-faces truncated at the top by the shelf and covered with gravel. We have found these rock-shelfs as far west as Seven Weeks' Poort on the Ladismith side; and they can also be very well seen at Meiring's Poort; between these two points there has been so vigorous an erosion that the traces of the old plateau have disappeared, yet it is abundantly evident that the plain did formerly exist here.

At Vlakte Plaats the shelfs run together and form a continuous high-level plateau. It is very interesting to notice here the remnants of another plateau only a hundred feet above the present flood-level, and still a third, which only recently has been abandoned by the river, and over which the railway between Jager's River and Uniondale Road is carried for some distance. In this one area, therefore, we have all the stages in the development of the plateaus, each formed during a period of no downward erosion of the river, due to stoppage in its course. The gravel covering the high plateau is in places exceedingly coarse, and the boulders are not rounded; the matrix is yellow clay not usually impregnated with iron, but which becomes flint-hard by the deposition of silica. The lower plateaus are not capped with gravel, but were once probably covered with soil, which has not had an opportunity of hardening, and has consequently been washed or blown away.

At Paarde Kloof there is an isolated hill to the west of the homestead, cut out of white gravel and sand belonging to the Enon Conglomerate, which dip steeply to the south-west; the summit of the hill reaches the level of the plateau, and is covered with the high-

level gravels. The latter consist of the very same pebbles that have been washed out of the Enon Conglomerate, some perhaps from the self-same beds in the upturned edges of which this re-made gravel rests (Plate X., fig. 3). This is an interesting point, as the high-level gravels so resemble in places the conglomerate of the Jurassic or Lower Cretaceous Beds that they can often be confounded, but here we have the most satisfactory demonstration that the high-level gravels are very long subsequent to the Enon Conglomerate.

Nearer the head of the river along the southern flanks of the Anthonie's Berg, the gravel becomes very thick; at the bottom is the normal gravel-capping cemented with iron, then comes a very thick deposit of coarse rubble, 80 to 100 feet thick, and on top of this again white, silica-cemented sand. The actual head of the river lies on the high plateau, and there is a wide area of rolling plains intensely cold in winter, at an elevation of 3,200 to 3,500 feet; it extends towards Willowmore, and forms a connecting bridge of high country between the Anthonie's Berg and the Baviaan's Kloof Mountains. From the head of the Oliphant's River one can look over Nieuwe Kloof and the extraordinary part of the country known as Baviaan's Kloof—both a kloof and a home of baboons *par excellence.*

The geology of Baviaan's Kloof needs a special paper. It is sufficient here to say that there are two great mountain ranges, the Kouga on the north and the Baviaan's Kloof Mountains on the south, rising to 5,000 and 6,000 feet; between them is a wide open plain at the normal elevation of the high plateaus, from 3,000 to 3,500 feet; the distance between the two crests is from nine to twelve miles, and the bevels go very high up the mountain sides, so that practically the whole of the intervening space is the double bevel itself (Fig. 4). In the centre are a number of narrow basins due to the letting down by folding of the Bokkeveld and Table Mountain Beds, and the Enon Conglomerate as well, that at one time lay upon these. To what depth the fold carried the last-mentioned beds we cannot judge, as the bottom of the present valley bottoms are choked with débris, and no borehole or well has been let down far enough to strike rock; the surface of the valleys is from 1,000 to 1,200 feet below the plateau. These little fold- or fault-basins—for the fold is so abrupt that it often passes into a fault—are strung on the Baviaan's Kloof River, like beads on a thread, the river between each basin running through tremendous winding gorges. All over the level country the gravels are strongly developed, and exhibit on the edges of the basins banks of gravel and hardened sand, some 40 to 60 feet thick. The edges are abrupt as

if cut out by denudation, and strongly suggest that at the time of the bevelling the whole of the basins were filled in; an additional evidence of this is that the Enon Conglomerate still left in the little basins occurs on the up-stream end; at the down-stream end it has all been carried away. The krantzes of gravel stand out perfectly vertical on the tops of very steep slopes, and from their nature are easily excavated into small caves and recesses. In these hollows the bees are very fond of building, but the nests are unapproachable; the Bushmen, however, determined to get the honey, used to drive pegs in the vertical face of the rock, and thus made a ladder by

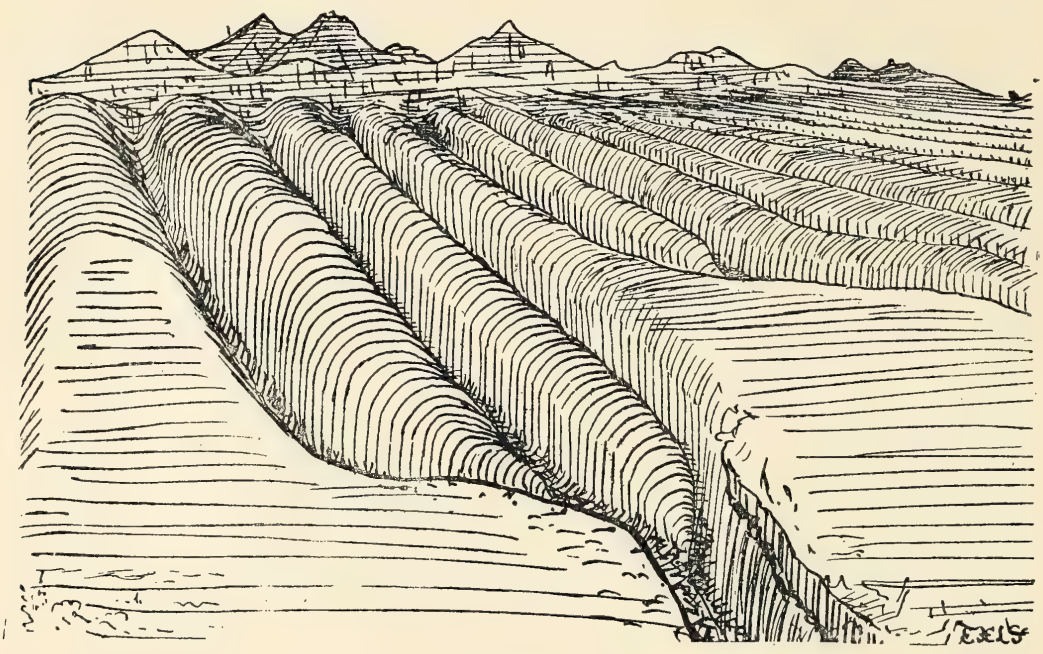


Fig. 4.

View of the Kouga Mountains near Beako's Nek, Baviaan's Kloof, showing the original bevel deeply incised by the stream-beds. The rock is Table Mountain Sandstone with vertical dip.

which to reach the nest; the pegs can still be seen in many places in Baviaan's Kloof, especially by Verloren River.

Turning now to the gravel-covered bevels north of the inner coast range, the Zwartebergen, we find but a few isolated patches of the gravel cap left. Near Floris Kraal, by Laingsberg, at Prince Albert village on the east, and near Klaarstroom on the Prince Albert road, there are unmistakable gravel plateaus, but whether these belong to the great system that we have been discussing in the inter-mountainous region is another thing. I believe the tops of the Witteberg hills here represent that period, and that the gravel caps just mentioned, except perhaps the Floris Kraal one, are on a lower level

—that is, belong to a later bevel of erosion. It is an extraordinary thing, that throughout the Witteberg hills which lie to the north of the Zwartebergen and are continued towards Grahamstown, the tops are all ground flat to a level from 3,500 to 4,000 feet above the sea, and this in spite of the fact that the strata of which they are composed are contorted into the most abrupt and intricate folds. On the inside of the Cederbergen we get the same Witteberg hills, but the strata there are lying almost flat, and the phenomenon of their being flat-topped did not therefore excite any particular attention when they were surveyed, but in spite of the horizontality of the component beds I now believe the actual summits of the hills are due to a base-levelling similar to that which has reduced the folded region to the east of them. Points on these hills do certainly rise so high that one cannot include them with the peneplain; for instance, the hill to the north of Willowmore called Aasvogel Berg, is 4,400 feet, but this, I take it, is either a portion that has escaped the levelling, forming, as it were, an island, or has since been raised by earth movements, either explanation being equally probable. To the east of Aasvogel Berg, however, the hills are cut strictly to a plateau which has now been worn into, and the softer beds removed, so that the country is one succession of steep valleys; yet the crests of the intervening ridges all touch a level sky-line, and occasionally also open flats still occur perched on top of the hills. These latter are very important economically, as the Witteberg rocks are not as a rule pervious to water, and the highly inclined beds of quartzite act like so many pent roofs, down the sides of which the rain-water rushes so impetuously that none is left to sink into the ground and nourish the vegetation that grows upon them; where these flats occur, since they include the softer rocks as well as the harder quartzites, the rain-water has a chance to sink in, and, as a result, they are covered with grass and luxuriant bush, and below them springs issue.

When one looks northwards from these hills in the region of Prince Albert, one notices an immense plain and then a ridge of hills; one can see the two very well from the railway between Prince Albert Road and Groot Fontein on the Western system. One at once notices that these hills to the north of the plain are all level-topped, or at any rate the summits of the ridges all rise to a certain elevation, no more and seldom less; this unmistakably indicates that they are remnants of a plain of erosion, as the beds of which they are composed are contorted, and had they not been so cut down they would have formed a series of jagged and irregular hills (Fig. 5). The height of the hills is from 3,000 to 3,500 feet, and

the plateau of which they are part must have at one time been very extensive. The Witteberg hills by Prince Albert, rising to 3,500 to 4,000 feet, are also part of a plain which at one time was very extensive, and thus it is almost certain that the two plains were at one time continuous, and that what remains of them now has been separated by the rivers, of which such mighty chisels of erosion exist in the Gamka or Lion River and the Dwyka. These northerly hills only extend as far as the Prince Albert Division; eastwards, beyond, we get the immense plains of the flat Karroo, the Beaufort, Aberdeen, Willowmore, and Graaff-Reinet flats, in which the rivers have an immense thickness of Witteberg quartzite to traverse, and have to do so along their strike, which is always the least susceptible to river erosion; the rivers, therefore, are to a certain extent dammed back and have cut out a plain exactly as I have supposed them to have done on a higher level in

Fig. 5.

M.C.S. Malmesbury Beds. **T.M.S.** Table Mountain Series. **BV.** Bokkeveld Beds. **WS.** Witteberg Beds. **DW.** Dwyka Beds. **E.** Ecca Beds. **BF.** Beaufort Beds.

Generalised Section from the Zwartebergen to the Prince Albert Goldfields, showing the old High-Level Plateau which has now nearly disappeared.

bygone days. Should a channel be cut through the Witteberg hills, by which a shorter passage could be obtained for the flood-water from these plains of the Flat Karroo to reach the ocean, there is little doubt but that the plain formation would be broken up, and a Rugte veld or Kopjes veld produced, as in the hills north of Prince Albert.

It is in these northerly hills that the gold has been found in the Prince Albert Division on the farms Spreeuw Fontein, Klein Water-val, and north of Commando Kraal. The gold has always been alluvial, for the most part being found in the mud and dirt extracted between the joints of the sandstones. Prospecting has everywhere been vigorously prosecuted, but up to the present no signs of any reef has been discovered. I have known these fields for ten years, and have always been very sceptical as to whether any gold-bearing reef will ever be found in this part of the Karroo; there are abundant quartz reefs, some pure, solid, white quartz, others locular, and

made up of small transparent yellowish crystals of quartz; these reefs fill cracks which have been caused by the contraction of this part of the earth's surface, probably due to the contraction after the heating produced by the injection of the dolerite sheets and dykes. The quartz has been deposited from water, and it is very improbable to my mind that the cracks can have penetrated sufficiently deep to allow the metalliferous solutions that came from the earth's interior to reach them. It is not, of course, impossible, for we know of springs in Nevada to-day that bring gold in solution to the surface, but in these comparatively recent rocks as those of the Karroo, that do not date back beyond the Permian or Trias, one does not look for metal-bearing reefs. The same opinion was expressed by Mr. Sawyer in his report on these fields. How, then, did the gold get to the Prince Albert gold-fields?

As a result of my recent survey I am very strongly of opinion that the gold came from the Zwartebergen, and was carried over to the various localities where it is now found, on top of the old high-level plateau. The evidence is satisfactory as far as I can make out, for the gold is found all along the belt of high country and nowhere else. If hearsay evidence can be admitted, it also points that way, for I heard stories that gold had been found recently on the top of the Witteberg hills at Zoetendal's Vley, and Mr. T. Bain records a find of gold near the same place in 1891. I heard similar stories that gold has been found in fallen blocks on the flanks of the Zwartebergen themselves, at Scotch Kloof on the farm Damascus. I state these facts simply as I heard them, and I had no means of sifting them to learn what amount of truth there was in them; when any one finds gold, he keeps the fact as secret as possible and certainly will not give any information to a Government official. Whether these finds have been gold or no, they occur in places where they very well might be, and the Zwartebergen do undoubtedly contain gold in small quantities, and it is quite possible that deposits may be found in them as rich as those in the Outeniqua Mountains in Knysna, which are in the same formation. Further, there exist in the Zwartebergen beds of true banket, which are no more than old gravels, and may, of course, be barren; but it is a significant fact that the Knysna gold is found in the immediate neighbourhood of similar beds of banket (Plate X. 4).

For a reason that is not yet sufficiently explained, where there is a deposit of sand and gravel, if there are any heavy metallic particles borne by the stream by which they are being deposited, it is always in the gravels that the metallic particles are deposited. On the Rhine and on the Irawadi River in India the sands are perfectly

free of any trace of gold, yet the gravels contain appreciable quantities, and such deposits have been worked from time immemorial; in a sandstone formation one, therefore, always looks to a banket or conglomerate bed as the one most likely to contain the precious metal.

The whole problem of the Karroo gold amounts to this: it is unlikely that reef gold occurs in the Karroo, while it certainly exists in the Table Mountain Sandstone of the Zwartebergen; by the knowledge that the localities where the gold is now obtained were once connected by a graded plain cut by rivers flowing north from the Zwartebergen, we have an adequate explanation of how the gold was carried from the one place to the other. There are no gravel caps to the hills on the Karroo gold-fields, and all signs of the flat ground have disappeared, but once the gold got to the place and the levelled hills became cut into the kopjes as they now are, the gold on top would sink with the sinking of the valleys, and instead of being carried off with the lighter sand, would be left behind and come to rest in the crevices of the rock, just as in actual sluice-boxes the gold grains come to rest in the furrows of the shoots.

The problem of the high-level gravels is one of altitude, and there are too few bench marks in the Colony to make any reasoning of the above sort perfectly satisfactory. I have throughout had to use rough estimates and calculations from bench marks up along assumed rates of increase in the falls of the rivers. It would be of very great value not only from a theoretical standpoint, but also from a practical one as well, if three or four carefully levelled sections were run from the coast inland; not only would we be able to discuss such apparently trivial things as the existence in past ages of old land surfaces, but one could gather from such sections a true idea of the present fall of rivers, and once that was obtained, we should no longer be in doubt about the various irrigation schemes that are continually being proposed—we should have solid data on which to base our estimates.

APPENDIX.

A SHORT HISTORY OF THE PRINCE ALBERT GOLD-FIELDS.

The first nugget that was found on the Prince Albert Gold-fields was obtained on the farm Spreeuw Fontein, by Mr. Lodewyk Botma, from the dirt thrown out by an Aard vaark (ant-eater) that was making a hole. The nugget weighed 2½ oz., and was rounded and water-worn, but had all the same a few crystals of quartz adherent. This was in 1871. The same year Messrs. Barry and Nephews, of Port Beaufort, employed Mr. E. J. Dunn to go and report on the find, but the result was an adverse opinion. So the matter rested till 1891, when a shepherd picked up another nugget on the adjoining farm Klein Waterval, weighing 6 dwt. 23 grns. Soon afterwards, or to be precise, on the 4th August, 1891, the farm Spreeuw Fontein (19050 morgen) was thrown open to the public, and on the 20th September the farm Klein Waterval (3898 morgen) was added to the public diggings. At the opening some 500 persons were present, and before the end of the year 1,042 claims had been registered and 504 oz. of gold obtained. The largest quantity obtained by one man was 100 oz., and this was on the claims belonging to Mr. P. H. du Plessis, the original prospector. Mr. Botma, the owner of Spreeuw Fontein, laid out a township which he proposed to name Gat's Plaats, I suppose in memory of the Aard vaark's hole. Interest gradually waned, and when I was there in 1895 working had fallen into the hands of a few poor coloured men; at last, in 1896, even the Registrar of Claims was withdrawn. Various attempts have been made to reawaken interest in the fields, and during the war there was a report of a new find of a large nugget, but all to no purpose. For some years now a small syndicate at Prince Albert has kept a prospector at work to the east of Spreeuw Fontein, on the Willowmore border, but the results of his work have not been made public.

REFERENCES TO REPORTS ON THE GOLD-FIELDS.

A. 29–71. Report on the indication of the existence of gold in certain of the Western Divisions of the Colony, by E. J. Dunn.

A. 30–71. Report on a tour made by Dr. W. G. Atherstone and Mr. Thos. Bain in connection with the gold discovery in the Gouph.

A. 12–91. Report of the Geological and Irrigation Surveyor (T. Bain) upon his recent investigation into the gold discoveries on the farms Spreeuw Fontein and Klein Waterval, with annexure by Mr. H. M. Oakley.

A. 13–91. Report upon the discovery of gold in the Division of Prince Albert by T. Bain.

G. 28–92. Report of the Inspector and Registrar of Mines, Prince Albert (H. M. Oakley), for the year 1891.

G. 45–93. Report upon the Geology and Mineral Resources of the Division of Prince Albert, A. R. Sawyer.

EXPLANATION OF PLATES.

Plate II.

South end of Meiring's Poort, east side. The bevel is shown cut in Cango Beds and Table Mountain Sandstone; it is seen rising rapidly towards the mountains on the left, the Zwartebergen, and in part is covered with coarse gravel. An enlarged portion of the gravel is shown in fig. 1, Plate III.

Plate III.

Looking eastwards from the fort on the south of the village of Uniondale. The valley and head of the Kammanassie River is seen below, and the Oude Post Berg on the extreme left. In the foreground is the irregular surface of the high-level river-deposit, here consisting of sand, hardened by deposition of silica till it is a compact mass of yellow quartzite; the rounded surfaces of the weathered blocks are wind- and sand-polished. In the distance the high-level plateau is well shown, and there is an isolated flat-topped hill in the centre, similar to that from which the photograph was taken.

Plate IV.

Fig. 1.—The coarse gravel capping the bevel terrace on the south end of Meiring's Poort, east side; it is seen from a distance in Plate I.

Fig. 2.—Roode Kop, Paarde Kloof, Uniondale. Recent gravel is shown resting on the upturned edges of Enon Conglomerate (Lower Cretaceous or Jurassic Beds).

Plate V.

A bed of banket in the Table Mountain Sandstone, Jager's River, Uniondale.

Gravel-Capped Bevel, East Side of Meiring's Poort, Oudtshoorn End.

West, Newman proc.

Gravel-Capped Hills East of Uniondale.

West, Newman, proc.

Fig. 1.

Near View of the Gravel Cap seen in the distance in Plate II.

Fig. 2. West, Newman proc.

Gravel Capping Up-turned Beds of Enon Conglomerate.

Bed of "Banket" in the Table Mountain Sandstone, Jager's River, Uniondale.

West, Newman proc.

THE SUTHERLAND VOLCANIC PIPES AND THEIR RELATIONSHIP TO OTHER VENTS IN SOUTH AFRICA.

By A. W. Rogers and A. L. du Toit.

(Read March 2, 1904.)

During the recent geological survey of Sutherland a considerable number of volcanic pipes were met with. They are all of a peculiar type, and are more nearly allied to the Kimberley pipes than to the more usual kind of volcanic vents that are represented in this country by the Stormberg necks.

In this paper we propose to describe these volcanoes, and to point out their relationship to similar vents in other parts of South Africa, and their more or less close resemblance to some foreign vents.

In the Sutherland Division the necks occur on the village commonage; on the farm Matjes Fontein, about nine miles south-east of the village of Sutherland; in the immediate neighbourhood of Saltpetre Kop, a short distance to the north-east of Matjes Fontein; on Blaauw Blommetjes Keep, 2½ miles north-west of the Kop; on De Vrede, to the south of Saltpetre Kop; and on the banks of Portugal's River, east of De Vrede. There are probably several others which escaped detection, but in the case of two shallow depressions about two miles east of Sutherland village some of the peculiar minerals characteristic of one class of the rocks occupying the pipes were found in the surface soil.

Many of the pipes are very inconspicuous, for their contents have weathered away slightly faster than the surrounding rocks, and the tendency to form a depression has been kept in check by the deposit of silt and sand over the areas, so that there is nothing to distinguish a depression due to the presence of a pipe from the shallow pans that are frequently met with in the Upper Karroo. Other pipes are fairly easily found owing to the weather-resisting qualities of some of the rock in them; and others again, such as the Saltpetre Kop group, are very conspicuous from that cause.

All the vents in the Sutherland Division are surrounded by nearly horizontal strata belonging to the lower part of the Beaufort series.

No fossils have been found in their immediate vicinity; but not far to the north-east of Portugal's River large bones belonging to *Titanosuchus* occur, and this is a genus which is found in the *Pareiasaurus* beds in the Gouph. To the west, in sandstones which have been followed round from the Roggeveld escarpment to the Komsberg, and which pass under the village of Sutherland, there are plants belonging to the genera *Glossopteris* and *Schizoneura.*

The Sutherland Commonage Group.

A few hundred yards west of the village there is a low escarpment of sandstones; from the edge of the escarpment the ground rises gradually to the steep dolerite-crowned hills of Vyf Fontein. It is on this sloping terrace that the vents we have now to describe are situated. The accompanying plan (Fig. 1) shows their distribution.

Vent No. I. is a roughly triangular area, well defined on the south-west, but covered with soil on the other sides. Two shafts for prospecting purposes have been sunk in this area, but they are now in great part filled up by fallen material. They are both in a soft, light bluish-grey tuff or weathered igneous rock, probably the former. The deeper shaft was sunk to a depth of 80 feet* without striking the unweathered rock. Near the south-western wall the tuff becomes a sandy breccia, and contains numerous angular fragments of sandstone and shale. Under the microscope the rock is found to consist of grains of quartz, flakes of brown mica, broken crystals of olivine augite and brown hornblende, and minute grains and crystals of iron ores and perofskite, set in a dusty matrix containing much calcite. In other parts of the vent there are outcrops of a grey rock with a compact-looking base crowded with crystals of olivine and pieces of ilmenite up to an inch in length. Many hardened fragments of shale are seen, and there are also flecks and small cracks filled with a mixture of calcite and zeolites. The specific gravity of a fresh specimen without large pieces of ilmenite is 3·11. Under the microscope the matrix is seen to consist of a matted aggregate of fibres with low double refraction which is attacked by dilute hydrochloric acid with separation of silica; in this matrix are magnetite or ilmenite grains, crystals of perofskite, apatite, melilite, grains of augite and olivine, though the augite is not abundant, and numerous flakes of a very pale biotite. The melilite occurs in colourless lath-shaped sections showing the

* For this and much other information about the prospecting operations in the Sutherland Division we are indebted to Mr. J. Kennedy, of Sutherland.

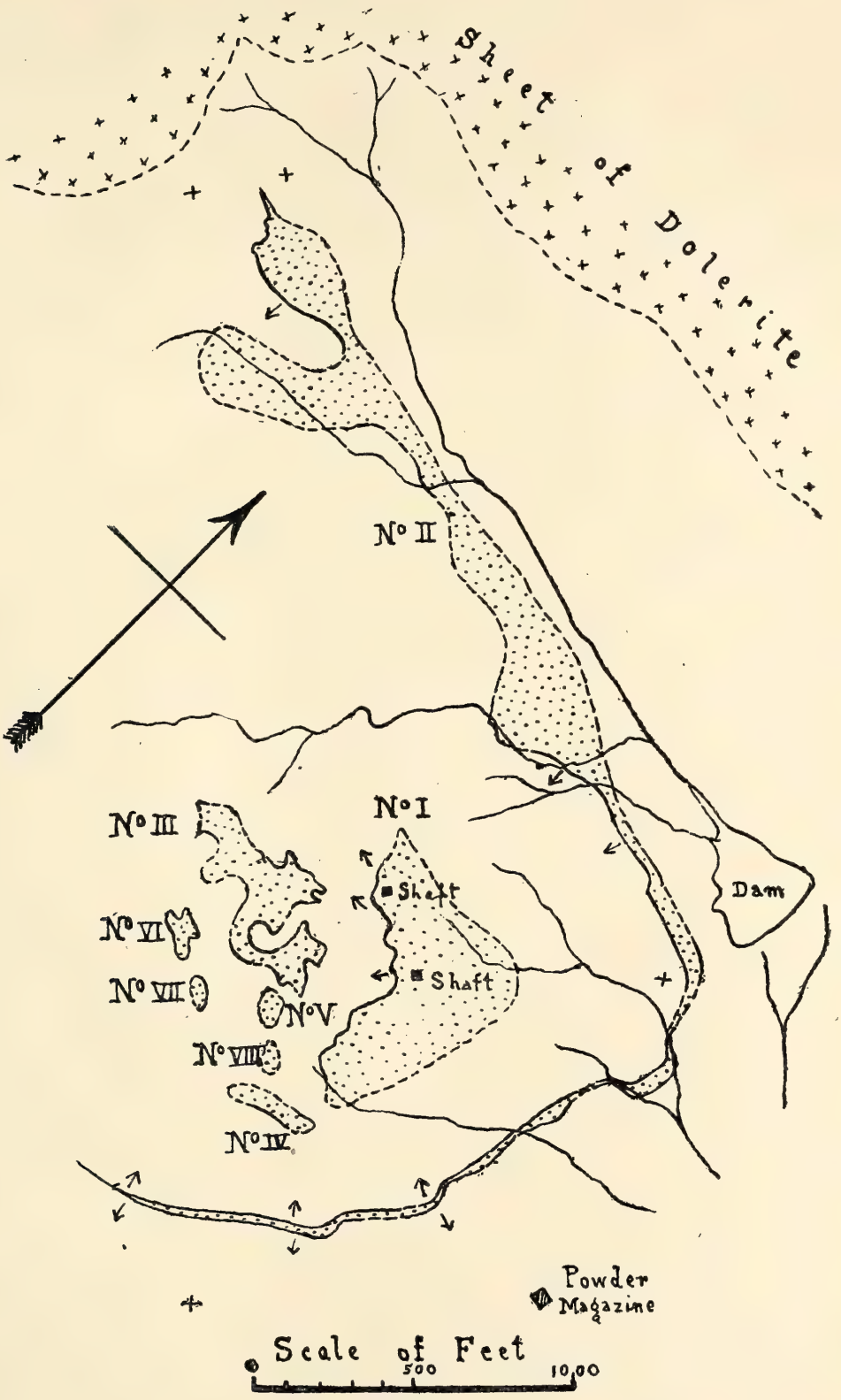


FIG. 1.

Plan of volcanic necks of Sutherland.

characteristic "peg-structure," but this feature is not so well developed as in the melilite of Spiegel River and Matjes Fontein; irregular patches of a colourless, almost isotropic, mineral are basal sections of the melilite. There is usually one cleavage crack in the lath-shaped sections, and the edges of the lath are irregular owing to the surrounding grains, particularly of magnetite and perofskite, projecting slightly into the melilite. The melilite gives the usual silica jelly on treatment with weak acid. The large olivine crystals are usually corroded but otherwise unaltered; they reach half an inch in length. The ground mass and smaller mineral constituents of the rock are enclosed within the corrosion cavities. No glassy matter appears to be left in this rock, but the fibrous ground may have been derived from glass.

This rock can be called a melilite-basalt, and its points of resemblance to others of a similar nature will be referred to later.

The contact with the surrounding sedimentary rocks can only be seen on the south-western edge of the pipe, but the thin sandstones and shales exposed there are distinctly hardened within a few feet of the pipe. A columnar structure, with the columns usually at right angles to the pipe wall, is well developed at places; sometimes the columns are arranged radially in bunches. The strata dip away from the neck at various angles up to 20°.

The pipe No. III is an irregularly shaped area of melilite-basalt with more melilite than the rock from No. I., but no pale-brown mica; olivine, perofskite, and magnetite are abundant. It contains inclusions of an earlier consolidated melilite-basalt with much pale biotite. The melilite is arranged in a stream-like fashion round the large olivine crystals. No tuff or breccia has been found in this vent, but its junction with the surrounding rocks is not exposed, and as there are no artificial excavations in it, the absence of tuff may be more apparent than real.

No. IV. is an elliptical area of melilite-basalt about 300 feet long and 100 feet wide. Its junction with the sedimentary rocks is hidden.

The remaining necks—Nos. V.–VIII.—are filled with rocks of quite different nature from those already described. They consist of altered vesicular lavas and rocks containing so much *débris* derived from sandstones and shale that they must be looked upon as agglomerates and not as igneous rocks charged with foreign matter No melilite-basalt has been noticed in these pipes. The boundaries of these vents as marked on the plan (Fig. 1) are not accurate; there is so much sand and gravel washed down from the hills to the west that they are for the most part hidden. There is no doubt as to the

separation of Nos. V. and VIII., and of these two from VI. and VII., but the outcrops represented on the plan by the two latter may belong to one pipe.

The rocks from these outcrops are mainly highly vesicular glass; when fresh they are dark in colour and somewhat banded. The vesicles are filled with calcite, analcite, and natrolite, besides other minerals that have not been determined. Quartz is not present in the vesicles, and only occurs in these rocks as grains of sand derived from sedimentary strata. In the fresher specimens the glass is isotropic and unaltered; in it lie large porphyritic crystals of olivine which are now entirely replaced by serpentine; a greatly altered fine-grained rock adheres to several of the serpentine pseudomorphs as though they really belonged to a rock of which fragments are enclosed by the glassy lavas. The original nature of this enclosed rock has not been made out. The glass also contains a mineral that occurs in small rectangular and hexagonal sections; the rectangular sections have straight extinction and the hexagonal ones are isotropic; both the refraction and double refraction are low. This mineral has the optical character of nepheline, but it does not give the chemical reactions characteristic of that species. It is frequently altered to a mass of greenish yellow granules. Very small crystals of augite, much magnetite, and minute needles of a doubly refracting mineral are also present. In the absence of a chemical analysis of the rock, it is impossible to decide upon its nature, but it is evidently a very basic glass. It has a strong resemblance to a thin glassy dyke found by Mr. Schwarz * some years ago at Kook Fontein under the Nieuweveld.

The only outcrop that remains to be mentioned is that of the curved dyke marked No. II. on the plan. It encircles the group of vents already described on the north and east. It is about $1\frac{1}{4}$ miles long and 700 feet wide across the forked eastern end, elsewhere its maximum width is 350 feet. In places east of the vents the dyke narrows down to a few feet. No tuff or ashy material has been met with along its course, and it appears to be a dyke rising more or less vertically through the sedimentary rocks. The rock is a melilite-basalt very like that in No. I. pipe, but it contains rather more cracks filled with zeolites. The ground mass is a felted mass of fibres with small crystals and grains of perofskite, magnetite or ilmenite, augite, flakes of pale biotite, and many crystals of melilite. Much of the melilite is partially altered to a fibrous mineral which polarises rather brightly when the fibres lie parallel, but in the more advanced stages of alteration the pseudomorphs become indistin-

* Ann. Rep. Geol. Comm. for 1896, p. 18.

guishable from the matted fibres of the ground mass. The large olivine crystals are in all respects similar to those in the other melilite-basalts. In all of these rocks the magnetite and perofskite grains and crystals are frequently arranged round the olivine crystals as a sort of border or frame. Some large masses of shale and grit many feet in length are enclosed by the melilite-basalt of this dyke.

The Sutherland Commonage vents, then, are of two kinds—one variety is filled with melilite-basalt alone, or with that rock and tuff; the second class is characterised by glassy and amygdaloidal lavas, and contains some gritty tuff or agglomerate. There is nothing to show which of the two classes was in activity first. The whole group of vents is partially surrounded by a curved dyke of melilite-basalt.

The Matjes Fontein Pipes.

On the farm Matjes Fontein, about 12 miles south-east from Sutherland village, there are two very interesting pipes; although they are ill-exposed at the surface, shafts sunk by a prospector enabled us to get a good idea of their nature. One of the pipes is situated $\frac{3}{4}$ mile south-south-east of the homestead, and the other is at Silver Dam, a portion of the same farm. The two will be referred to as the Matjes Fontein and Silver Dam pipes.

The Matjes Fontein pipe has two pits sunk in it, one of which cuts through the contact with the country rock, a greenish sandy shale which dips at a high angle away from the pipe. This dip does not extend far, as there are outcrops of sandstones and shales lying nearly horizontally a few yards from the pipe. The size of the pipe cannot be determined closely, but it is about 100 feet wide. Near the contact with the green shale the contents of the pipe are an agglomerate with a soft earthy matrix with much sandy matter in it. The included fragments are mica plates up to an inch in diameter, large lumps of ilmenite, irregularly shaped lustrous black hornblende up to 3 inches in length, many pieces of shale and sandstone derived from the Karroo formation, and large fragments of granite and gneiss. The large fragments are angular or partially rounded and they are scattered irregularly through the sandy matrix. Near the second shaft there is a boulder of dolerite several feet in diameter; its relation to the pipe is not absolutely certain, for it projects from the soil and the surrounding rock is not laid bare. There is, however, no doubt that it lies within the pipe, and as it cannot be a boulder derived from dolerite now exposed at the surface, for the nearest dolerite outcrop is more than a mile away, it is very probably a block of dolerite lying in the agglomerate. In the second

shaft there is melilite-basalt, dull greenish-black in colour, with large crystals of dark mica up to half an inch in diameter, and smaller green crystals of olivine are clearly seen on a freshly broken surface. It effervesces freely with dilute acid owing to the abundance of calcite. Under the microscope the rock is seen to consist of olivine and a very pale biotite set in a mass of melilite laths, magnetite, perofskite, and grains of calcite; a comparatively small quantity of fibrous matter, resembling the ground-mass fibres in the Sutherland Commonage rocks, is also present and may represent a former glassy basis. The melilite crystals are arranged roughly parallel to each other and to the long axes of many of the olivine crystals, thus giving the rock a distinct flow-structure. The melilite crystals average ·1 mm. in width and about ·01 mm. in thickness; the mineral is colourless or very slightly tinted yellowish-pink. The peg-structure is well developed. The melilite is attacked by hydrochloric acid with separation of gelatinous silica. In the character of its double refraction, which is positive, it differs from the melilite known from the other melilite-basalts of the Colony. The pleochroism of the pale brown mica has a most remarkable peculiarity, the greatest absorption of light takes place when the traces of the basal cleavage planes lie perpendicularly to the short diagonal of the polariser. It is rather more strongly pleochroic than the biotite in the Sutherland pipes. In the strength of its double refraction it resembles the latter. The olivine is usually fresh, but alteration to serpentine has taken place along some cleavage cracks; it encloses patches of ground-mass, flakes of mica, and magnetite, but not melilite or perofskite. Both magnetite and perofskite are often arranged as a border to the olivine crystals. The abundance of calcite in this rock is difficult to account for. The constituents mentioned above are very little altered, and the melilite, which contains more lime than any other constituent except the calcite, shows no sign of alteration. It is unlikely that the glass basis contained so much lime as to give rise to the amount of calcite present. The surrounding Beaufort beds do not contain much calcareous matter. It is possible that water containing carbonate of lime in solution made its way through the pipe in an upward direction after the activity at the vent ceased, but in this case it is remarkable that so little change was induced in the older constituents of the rock. The calcite does not fill spaces of the nature of steam holes, but occurs in small grains with partial crystalline boundaries scattered throughout the rock. But for the difficulty of imagining calcite to form from a molten siliceous magma the mineral in the Matjes Fontein pipe might well be considered to be an original constituent.

The Silver Dam pipe lies a little more than a mile to the north-east of the vent just described. A shallow pan marks the position of the pipe, but it is not conterminous with its boundaries. The agglomerate of the pipe does not crop out at the surface, and it was only from the material piled round the top of two deep shafts made by a prospector that we could obtain specimens of the rock. As the materials from the two pits are rather different they will be described separately. The boundaries of the vent are ill-defined, but it is about 180 feet in diameter.

The rock from the south-western shaft, the one sunk within the shallow pan, is a soft blue-grey material crowded with fragments of rocks and minerals. Amongst the rocks are shales and sandstones evidently derived from the Karroo formation, quartzites, dolerite of the Karroo type, granulite, and peculiar rocks allied to the eclogites; with these there are numerous fragments of minerals that are the most conspicuous constituents, black mica, hornblende, augite, and ilmenite. Under the microscope the matrix is seen to consist largely of calcite in which there are crystals of perofskite, iron ores, fibrous serpentine, and dusty matter that cannot be determined; in this matrix lie fragments of the minerals mentioned above. The monoclinic pyroxene is of four varieties: (1) Almost colourless with very well-developed prismatic cleavage; it occurs occasionally in well-formed crystals and is identical in character with the augite in one of the granulitic rocks present in the form of fragments in the pipe. (2) Colourless with many diallagic inclusions; the prismatic cleavage is less well developed than in the first variety. It encloses felspar laths ophitically, and is evidently derived from olivine dolerite of the Karroo type. (3) A very pale green pyroxene with very slight pleochroism derived from one of the eclogites. (4) A bright green distinctly pleochroic mineral, a chrome diopside, derived from one of the granulitic rocks; it has the prism cleavages very well developed. The hornblende is in large fragments; it has a brown colour and moderately strong pleochroism. It also occurs in conjunction with biotite and ilmenite, and is certainly derived from one of the eclogite-like rocks. Mica is present in large and small flakes; a biotite with rather weak pleochroism is abundant, but another variety with strong pleochroism is also there. All these minerals are rather altered on the outside; the coloured ones are bleached, and contain dusty inclusions. In addition to these minerals there are also apatite, garnet, and a plagioclase felspar considerably altered. The sandstone and shale fragments are altered to a depth of about $\frac{1}{3}$ inch; they are lighter in colour in that zone than within it. There are three varieties of heavy basic rocks found as fragments

up to a foot in diameter. (1) A dark rock with many garnets visible to the naked eye. Its specific gravity is 3·15. The mineral constituents are almost colourless augite, brown hornblende at places intergrown with the augite, a very basic plagioclase, pale pink garnet always surrounded by a dark rim of alteration products, and ilmenite. The structure of the rock is granulitic, and crystalline forms are rarely seen. (2) A black rock with specific gravity 3·23; it is composed of pale green augite, strongly coloured brown hornblende, strongly pleochroic brown mica, ilmenite, calcite filling up cavities within the augite, mica and ilmenite, apatite, and a cloudy alteration product. No felspar is visible. The augite and hornblende tend to form aggregates of considerable size from which the other constituents are excluded. There are several intermediate varieties between these two, which appear to be respectively the least and most basic representatives of one rock mass. (3) A banded black and white granulitic rock. The mineral that appears to be black in a hand specimen is brilliantly green in thin section and it is a chrome-diopside in irregular rounded grains. The white portion of the rock is a cloudy mass (saussurite) of greatly altered felspar. A considerable amount of apatite is present. None of these eclogites or granulitic rocks is known *in situ* in the Colony, but the more basic black varieties present points of resemblance to rocks that are found as inclusions in the blue ground of the pipes north of the Orange River.

From the second shaft, a short way to the north-east of the one from which the rocks just described were obtained, there came an agglomerate with a harder matrix than that from the south-western pit. The matrix is less serpentinous and more sandy; if it were destitute of inclusions it might even be called a calcareous clayey sandstone, but microscopic examination of a thin section reveals the presence of serpentine, perofskite, iron ores, and ilmenite. The included fragments visible to the naked eye are sandstone, quartzite, shale, augite, mica, hornblende, and ilmenite, all similar to those described from the other shaft; chrome-diopside is rare; serpentine pseudomorphs after olivine are not uncommon. Dolerite of the Karroo type is frequently seen in this rock. All these fragments are outlined by a narrow band of altered material.

The Silver Dam breccias have a close resemblance to the Kimberley blue-ground, from which they chiefly differ in being less serpentinous; the minerals enstatite, smaragdite, orthite, tourmaline, epidote, and diamond, which occur more or less sparsely in the blue-ground have not been found at Silver Dam. We shall return to this question after the description of the other pipes.

The Saltpetre Kop Group.

Saltpetre Kop, or Old Sneeuw Kop as it is called on the maps, is a prominent peak about 12 miles south-east of Sutherland. It stands some 5,500 feet above the sea and 1,000 feet above the country at its base. The peak is formed of a hard siliceous and ferruginous agglomerate, part of a large vent which is 1,000 yards long. Other portions of the agglomerate in the vent are soft and do not stand out from the surface. This large vent is the chief one of a group of at least twenty distinct necks and over forty dyke-like outcrops of agglomerate and tuff. The arrangement of the necks and dykes is shown in the accompanying plan (Fig. 2), and the section (Fig. 3) gives an idea of the relation of the necks to the surrounding sedimentary beds. The latter have been bent upwards into a dome, so that they dip away from the central vent on all sides. The angle of dip is greatest near the centre and decreases gradually; at a distance of from $1\frac{1}{4}$ to 2 miles from the highest peak the dip due to the local up-thrust is no longer determinable. In most volcanic centres a slight dip towards the vent is seen in its immediate neighbourhood, but it only effects the rock within a few yards of the wall of the neck; the outward dip noticed at Saltpetre Kop and other pipes of the type we are here dealing with seems to be quite abnormal. The Saltpetre Kop dome remains one of the old illustrations of the "craters of elevation," though it must be remembered that the strata with the outward dip in the latter are of volcanic origin, and not ordinary sandstones and shales as in the case of Saltpetre Kop. It has long since been recognised that the dip of the volcanic beds round vents is entirely due to their manner of deposition, and that the strata through which the necks were blown are very slightly if at all arched upwards by the explosive agency that gave birth to the volcanoes. The Saltpetre Kop dome is all the more striking in that it is situated well within the great interior region of the Colony, where the rocks lie nearly horizontally It is like a solid blister raised in these horizontal strata. There can be no doubt whatever that the dome is due to the force exerted during the formation of the great vent.

The other nineteen are of much smaller size than the great central one, and are not arranged quite symmetrically about it. There seem to be no necks south-east or east-south-east of the large one, though it is possible that one or more vents filled with a soft agglomerate or tuff may have escaped notice, or may be buried under some alluvial deposits that lie in that direction. The small vents do not appre-

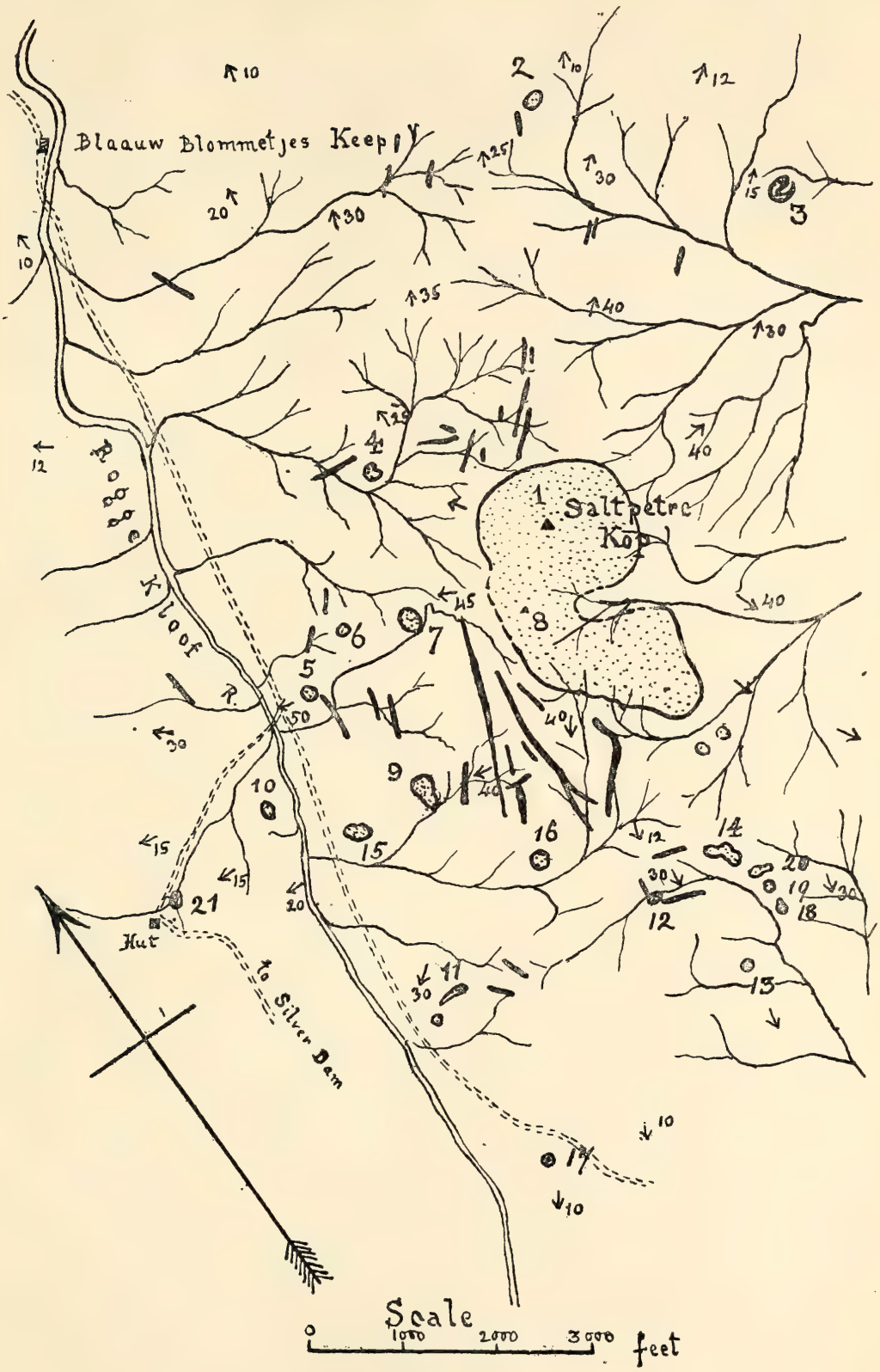


FIG. 2.

Plan of Saltpetre Kop.

The dotted areas represent pipes, and the thick black lines dykes.

ciably affect the quâ-quâ-versal dip of the Beaufort beds due to the main vent.

As fuller details of the various tuffs and agglomerates—using the former term for the fine-grained and the latter for the coarse-grained rocks—have been given elsewhere, * we shall not repeat them here, but we may summarise the main characters of these remarkable breccias. The coarse agglomerates are made of a sandy matrix with angular lumps of sandstone, shale, mudstone, and occasional pieces of quartzite, granite, mica-schist, and dolerite of the Karroo type; amongst the smaller constituents are felspar (orthoclose and microcline), ilmenite, brown mica, and hornblende. The last three minerals are similar to those in the Matjes Fontein and Silver Dam pipes. It is remarkable that no fragments of granulites or eclogites that are such conspicuous constituents of the Silver Dam breccia have been found at Saltpetre Kop, nor have olivine, augite, melilite, or perofskite been seen in specimens of the Saltpetre Kop agglomerates. The coarse parts of the agglomerate are sometimes rather cavernous, and the spaces may be lined with small quartz crystals. The agglomerates show no signs of bedding, but in the south-eastern portion of the large vent, which is occupied by rather fine-grained tuff, the rock is distinctly bedded, although the dips vary greatly within short distances. This tuff probably fell back into the vent after an explosion or was washed into it from the surface of the crater. Some of the quartzite fragments are of a remarkable shape; they looked like ordinary water-worn pebbles which have been battered; they are covered with shallow depression which are not sufficiently large to interfere with the general oval form of the pebbles. Similar quartzite pebbles were found in the pipes on De Vrede. Many parts of the agglomerates and tuffs were impregnated with silica and hydrated ferric oxides. When there is a moderate amount of iron present these silicified rocks have a striking resemblance to some of the surface quartzites of the southern and western districts of the Colony, but the similarity is, so to say, accidental, for there can be no two fragmental rocks with more dissimilar origins than these. Their resemblance consists in the silicification of detritus largely composed of quartz grains. The specific gravity of an average specimen with much ferric oxide is as high as 3·4. This accession of silica and ferric oxide has taken place to a greater extent in the peripheral parts of the agglomerate than elsewhere, and it also affects the sedimentary beds near the vents and dykes. Carbonates of lime, magnesium, and iron are also present in the agglomerates and tuffs, as well as barytes. The

* Ann. Rep. of the Geol. Comm. for 1903.

deposition of these minerals is very probably due to the passage of water charged with them after the explosive action had ceased: an analogous process to the solfataric stage of ordinary volcanoes.

Forty-six dykes filled with material apparently similar in general character to the agglomerates and tuffs of the vents have been noticed within a short distance of the central peak; some of them are shown on the plan. The longest dyke is over 700 yards in length. The majority have a north-north-easterly trend. Few of the dyke rocks have been examined in detail. A specimen taken from the longest dyke is seen under the microscope to be made up of small but well-preserved felspar laths imbedded in a very fine-grained matrix of interlocking crystals, the nature of which has not been made out, but they may be felspar. The felspar laths are andesine or albite. A porphyritic crystal of felspar contains small flakes of strongly pleochroic biotite, the only ferromagnesian mineral seen in the specimen. Apatite is present, as well as much calcite in the form of minute crystalline grains scattered through the matrix and as pseudomorphs which show rectangular, hexagonal, or irregular boundaries. No other sign of the original nature of this mineral has been observed. In addition to these constituents there is much hydrated ferric oxide. This rock is undoubtedly an igneous one, and up to the present it is the only rock from the Saltpetre Kop vents and dykes that

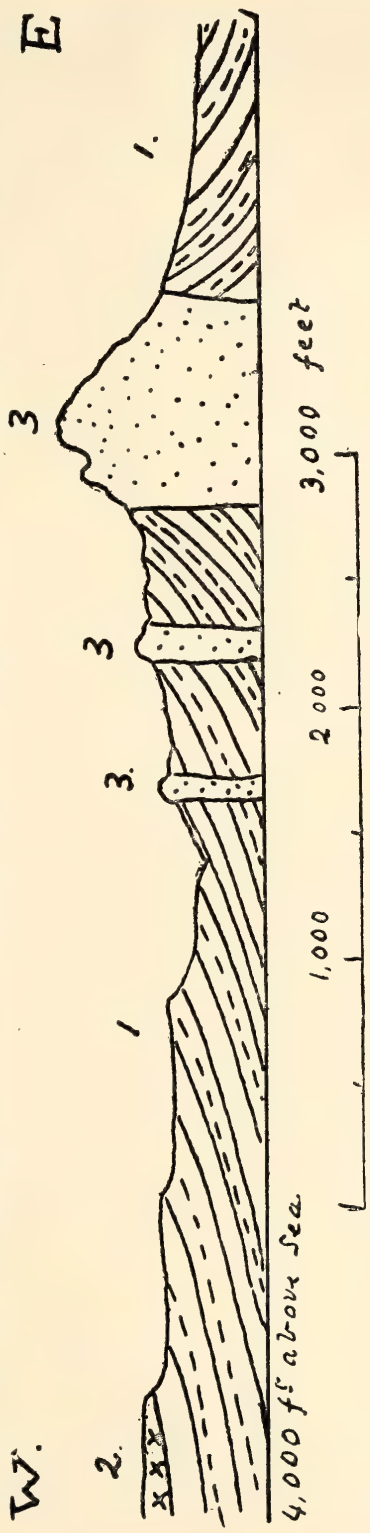


Fig. 3.

Section through Saltpetre Kop to show relation of the pipes (3) to the surrounding rocks, Beaufort beds (1) and dolerite sheets (2).

approaches an ordinary igneous rock in character. One of the other dykes is shown by a microscopical examination to be of precisely the same nature as one of the gritty calcareous tuffs of the vents.

On the farm De Vrede, at a distance of 2½ miles south-south-east of the central vent of Saltpetre Kop, there are two necks of the Saltpetre Kop type containing a yellow gritty rock with many fragments of quartzite, sandstone, and shale. One block of sandstone in this agglomerate is over 10 feet in length. From one of the vents a dyke runs northwards through the Beaufort beds; it is a yellow, earthy-looking rock containing both sulphate of barium (barytes), and carbonate of lime, and also numerous flakes of black mica. The carbonate of lime forms long lath-shaped crystals, probably pseudomorphs after another constituent.

On Portugal's River, 3 miles east of the De Vrede necks, there is a long curved dyke of coarse agglomerate, which was traced over 500 yards through the veld; at one place it is 80 yards wide. It is composed of a ferruginous agglomerate of sandstone and shale fragments; calcite and gypsum are found in cavities and cracks in this rock. The sandstone fragments are often of large size, blocks 5 feet in length are not uncommon.

On the farm Blaauw Blommetjes Keep, 2½ miles north-west from Saltpetre Kop, there is a wide area of agglomerate, which may be a neck; from it a sheet-like extension of fine-grained tuff passes across the nearly horizontal sandstone and shales of the Beaufort series and also through a dolerite sheet, a point of great interest, as it confirms the evidence given by the dolerite fragments in the Matjes Fontein, Silver Dam, and Saltpetre Kop breccias, that the necks were posterior in date to the dolerite intrusions (see Fig. 4). The tuff is very different in appearance at different spots; the bulk of it is a dull, rather decomposed-looking rock with numerous flakes of black mica, and it is highly calcareous. Other parts are more compact, and are heavily charged with iron oxides and calcite: numerous angular pieces of sandstone and shale are seen in the ferruginous rock.

Summary of the Sutherland Pipes.

The above descriptions of the various pipes in the Sutherland Division shows that they may be roughly divided into three classes:—

(1) Those filled with purely igneous material, either melilite-basalt or a basic glassy lava. These are confined to the Sutherland Commonage.

(2) Vents occupied partly by melilite-basalt or glassy lava and partly by agglomerate or tuff. In this class are the large vent

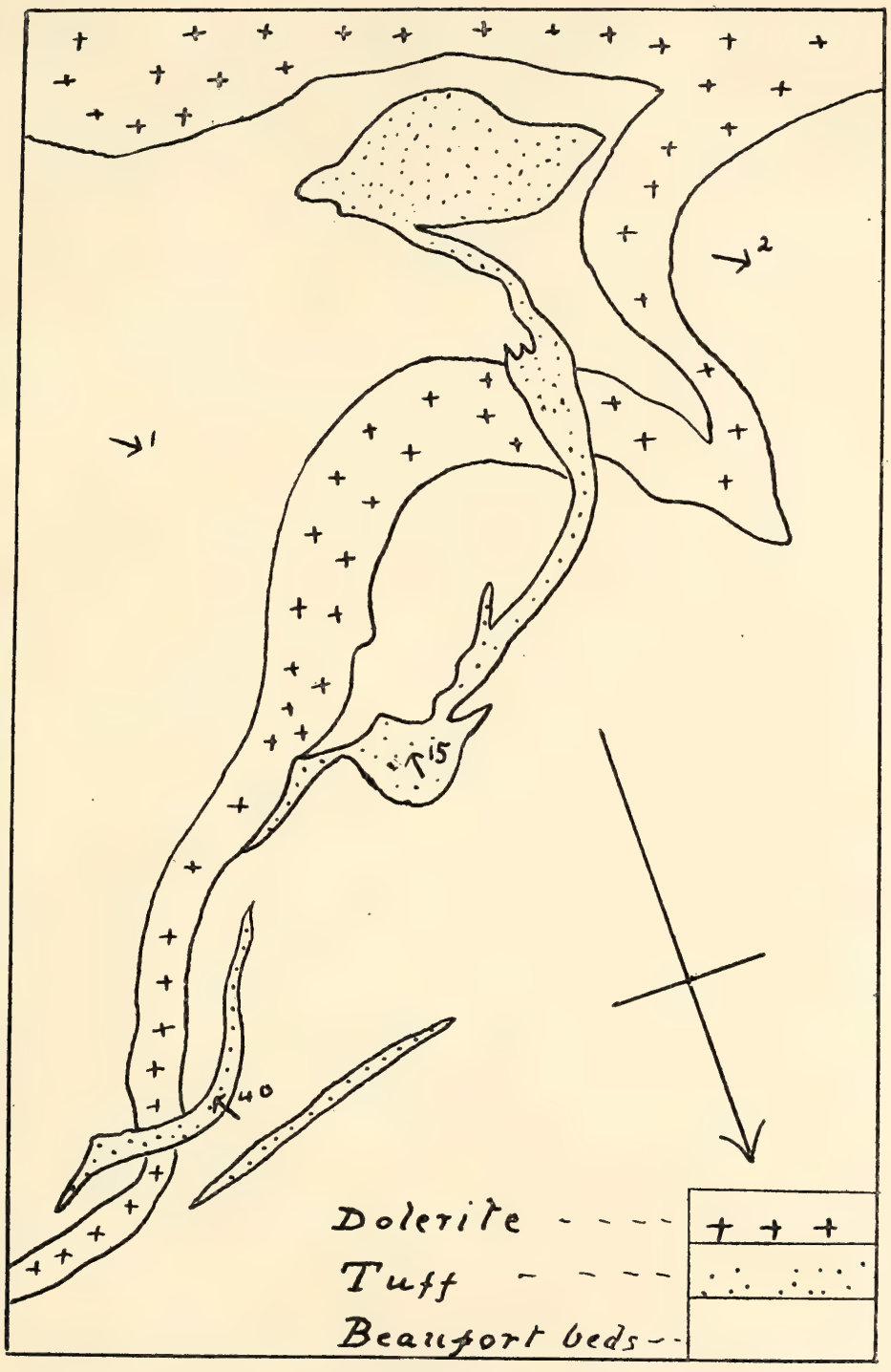


Fig. 4.

Plan of agglomerate and dolerite at Blaauw Blommetjes Keep.

and some of the smaller ones on the commonage, and the Matjes Fontein pipe.

(3) Necks of agglomerate or tuff, including all the Saltpetre Kop vents and that of Silver Dam.

While there are very great differences in the materials filling these vents they have one feature in common; they differ very greatly from the contents of the volcanic pipes of Stormberg age in the east of the Colony. The Stormberg volcanoes are occasionally penetrated by dolerite dykes, and if this dolerite be regarded as belonging to the same great system of intrusions of similar nature stretching from Calvinia to Natal, then the fact that the Sutherland volcanoes are of later age than the dolerite of that district proves them to be younger than the Stormberg volcanoes. There is no direct evidence of their relative ages; so far as we know at present the vents of Stormberg age do not occur west of the Molteno Division, and the volcanoes of the type we are now dealing with have not been found so far to the east.

Comparison with the Stormberg Volcanic Rocks.

The contents of the Stormberg vents and the lavas and tuff that accompany them are of a different nature from those connected with the Sutherland pipes. In the first place the Stormberg lavas are thoroughly doleritic or basaltic in composition; they belong to the great group of basic igneous rocks, of which labradorite or an allied species of felspar and augite are very important constituents.* Fragments of these basaltic lavas are abundant in the Stormberg vents, and they differ from the blocks of dolerite in the Sutherland vents in being glassy and often vesicular instead of holocrystalline dolerites; they are also much more abundant than the dolerite fragments occasionally found in the western agglomerates. The only igneous rocks in the Sutherland vents, other than those forming boulders, are melilite-basalts or very basic glasses, rocks which are much more basic than the Stormberg lavas. The felspathic rock forming one of the Saltpetre Kop dykes is an exception to the general rule that felspar is absent or very rare in the western rocks, but this dyke has at least no obvious resemblance to the Stormberg lavas or the dolerites.

Many of the Stormberg vents are filled with agglomerate or tuff largely composed of *débris* of sedimentary rocks or of deep-seated igneous ones such as granite, but hitherto no trace of the peculiar mica, diopside, hornblende, ilmenite, garnet, and perofskite, which are such conspicuous constituents of the Suther-

* See Cohen, "Neues Jahrbuch für Min. Geol. and Pal.," 1875, 113–127 Schwarz, Geol. Comm. (1903), Report on Matatiele.

land breccias, have been found in them,* nor have the fragments of eclogite.

Comparison with the Kimberley and Other Pipes North of the Orange River.

The constituents of the Kimberley group of pipes are fairly well known, thanks to the many mineralogists who have examined the materials brought to light by the progress of mining operations, but less information is available concerning the Jagers Fontein, Monastery, Pretoria, and other mines outside the Kimberley area.†

The more important constituents of the Kimberley blue-ground are the following: Olivine and its alteration product serpentine, enstatite (bronzite), chrome diopside, smaragdite, biotite, garnet, perofskite, magnetite, chromite, picotite, ilmenite; the less abundant minerals are apatite, epidote, orthite, tremolite, tourmaline, rutile, sphene, leucoxene, and diamond.‡ The rhombic pyroxene, enstatite or bronzite, which is usually considered to be an important constituent, seems to have been much more abundant in the earlier worked blue-ground than in the later worked rock obtained from greater depths.§ An examination of some specimens in the South African Museum from the lower levels in de Beer's Mine reveals a very small amount of this mineral. Enstatite is an abundant mineral in an enstatite-garnet-augite-hornblende rock from the Monastery Mine (O. R. C.) preserved in the Museum. As a result of his examination of the blue-ground or Kimberley, Professor Carvill Lewis came to the conclusion that it was related to melilite-basalt, though owing, as he suspected, to the alteration his specimens had undergone, the melilite could not be identified.|| The intimate association of melilite-basalt with breccias which have a distinct similarity to the blue-ground, though differing from it in the greater abundance of *débris* derived from sedimentary rocks and, in the case of the Matjes Fontein pipe, from deep-seated acid igneous rocks, is certainly very suggestive, and warrants the expectation that melilite rocks will one day be found with the typical blue-ground at Kimberley. As we have stated on a previous page, the melilite-basalt has not been met with at Silver Dam, nor is the breccia in the

* See Schwarz, *op. cit.*, p. 54.

† The most useful publications dealing with the constituents of the Kimberley group are: N. S. Maskelyne and Flight, Q. J. G. S., xxx., 1874, pp. 408–416; L. de Launay, "Les diamants du Cap," Paris, 1897; H. C. Lewis, "Genesis and Matrix of the Diamond," London, 1897, edited by Professor Bonney.

‡ Taken from Lewis, *op. cit.*, Sect. II.

§ See Bonney, *Geol. Mag.*, 1895, p. 496.

|| Lewis, *op. cit.*, p. 49.

Matjes Fontein pipe identical with that of Silver Dam, but the proximity of the two pipes and their general resemblance leave no doubt as to their close relationship. Amongst some specimens sent to the South African Museum from Kimberley there is one labelled by the donor "aphanite in blue-ground," which seems to occur as a fine-grained rock forming a narrow dyke in the blue. This rock is composed of small but well-shaped crystals of olivine, very slightly altered to serpentine along cleavage cracks, lying in a ground mass of calcite, magnetite, and perhaps ilmenite, perofskite, and a few irregularly shaped fragments of a pale biotite. The calcite is very abundant and conceals other constituents than those mentioned, but when it is removed from a slice by means of dilute acid a considerable quantity of indeterminate substance remains, which yields gelatinous silica on treatment with hydrochloric acid. The rock is evidently an igneous material injected whilst in a molten condition, for it has none of the characteristics of the breccias, broken crystals of olivine, garnet, diopside, and fragments of shale being absent from it. It resembles in general appearance the melilite-basalt of Matjes Fontein, but melilite is not visible in the specimen we have examined. So far as we know it is the first example of an ultra-basic igneous rock recorded as probably forming an intrusion in the blue-ground. Further information concerning intrusions of this type will be most interesting. The name "aphanite" merely indicates that the constituents are not large enough to be visible to the naked eye. The term has been especially used in connection with fine-grained augite-labradorite rocks, with which the Kimberley specimen has no relation.

The so-called "snake-rock" of the De Beer's mine is merely a hard variety of blue-ground apparently forming a dyke in the softer blue and passing outside the limits of the pipe into the surrounding rock (a quartz porphyry) at the 1,700 feet level.* The chief difference between thin sections of the "snake" and the blue-ground is that the olivine is less altered in the former than in the latter.

Amongst some specimens of the inclusions from the blue-ground of the Monastery Mine, about 30 miles south of Winburg, O. R. C., in the South African Museum there are rocks with similar characters to the eclogites and related rocks of Silver Dam. One of these has already been mentioned; another consists of bright green augite containing chromium, colourless augite, biotite, olivine, garnet, and ilmenite; and a third one of olivine, pale green augite, colourless augite, and pale biotite. Olivine is not abundant in the rock con-

* This fact was communicated in a letter to one of the writers by Mr. T. E. Robertson, for a time lecturer in the School of Mines, Kimberley.

taining chrome-diopside, but it has not been found in the rock fragments from Silver Dam, although it is abundant as isolated and serpentinised crystals and fragments in the breccia.

In some rounded fragments of eclogite from the Newlands mine in Griqualand West, Professor Bonney * found garnet (pyrope), a chrome-diopside of a much paler colour than the bright green augite mentioned above from the Silver Dam and Monastery Mine rocks, but apparently similar to the pale green augite of those rocks, and small octahedral diamonds. He indicates the bearing of this discovery on the origin of the diamond, which belongs primarily to the holocrystalline ultrabasic rock and not to the blue-ground. The evidence brought forward in his paper appears to be quite conclusive on this point.

The Newlands Mine is on the Harts River, north-west of Kimberley. The blue-ground fills an irregular pipe and fissures in slates and other rocks belonging to the pre-Cape rocks of Griqualand West,† but at the surface the pipe is surrounded by shales of the Karroo formation as at Kimberley. The accounts of the serpentinous breccia in dykes is interesting, and affords a parallel to the breccia dykes of Saltpetre Kop and other localities in Sutherland.

Comparison with the Pipes South of the Orange River.

In Mr. Dunn's paper, "On the Mode of Occurrence of Diamonds in South Africa," ‡ there is a short description of a pipe at Schiet Fontein, Carnarvon, which is surrounded by shales turned up at the contact with the breccia. No particulars of the contents of this pipe or those near Hanover are known. At Balmoral (Ratel Fontein) in the Fraserburg Division there is an admirably exposed pipe.§ The surrounding rocks are sandstones and shales belonging to the middle part (probably the *Dicynodon* beds) of the Beaufort Series, and they dip away from the pipe. The pipe is about 300 feet in diameter and nearly circular. The contents are more easily weathered than the surrounding rock, so the pipe is marked by a depression from 10 to 20 feet deep, with a vertical wall formed by the Beaufort beds, except at one place where the surface water drains off through a narrow gap in the sandstone wall. The material filling the pipe is a soft blue clay containing fragments of shale, sandstone, dolerite of the Karroo type, ilmenite, garnet,

* *Geol. Mag.*, 1899, pp. 309–321.

† See W. Graichen, "Die Newlands-diamantminen, Sud Africa," Zeitschrift fur praktische Geologie, xi., 1903, pp. 448–452.

‡ Q. J. G. S., 1874, pp. 54–60.

§ Rogers and Schwarz, Ann. Rep. Geol. Comm. for 1900, pp. 60–61.

and biotite; these are the only minerals and rocks yet observed in the Balmoral breccia. This vent is evidently similar to the Silver Dam pipe, but up to the present it has yielded a smaller variety of rocks and minerals than that one.

On the farm Spiegel River in the Division of Riversdale there is an outcrop of melilite-basalt in the Uitenhage beds.* It is more or less oval in outline and about 300 feet in its longer diameter. The rock stands out from the softer Uitenhage beds, but there are no sections showing the junction, and as the surrounding rocks are sandy conglomerates with feebly-developed bedding planes the change of dip, if it exist, near the igneous rock is not observable. The only reasonable explanation of this singular occurrence is that the basalt fills a pipe or neck. It is the only igneous rock of post-Uitenhage age in the Colony whose date is proved.

The rock is composed of porphyritic crystals of olivine lying in a base of melilite, augite, perofskite, magnetite, and glass. It has a very strong family likeness to the melilite-bearing rocks of Sutherland Commonage and Matjes Fontein, but is not identical with any one of them. Its chief points of difference from those are its freshness: hardly any sign of alteration can be seen; the only obvious change is the formation of serpentine along some of the cleavage cracks in the olivine; the augite is very pale green in colour and is an abundant constituent in the form of grains and crystallites; this mineral is not abundant in any of the Sutherland specimens yet examined, and is entirely absent from some of them; calcite is not seen in the Spiegel River rock, though it is abundant in those from Sutherland; and biotite is entirely absent.† In spite of these

* See Ann. Rep. Geol. Comm. for 1898, p. 62.

† Mr. J. Lewis, of the Government Analytical Laboratory, very kindly made a complete chemical analysis of the Spiegel River rock, with the following results:—

SiO_2	36·15
TiO_2	2·30
Al_2O_3	15·18
Fe_2O_3	4·87
Cr_2O_3	·10
FeO	9·11
MnO	·33
CaO	11·40
MgO	13·63
BaO	·06
Na_2O	2·42
K_2O	1·81
P_2O_5	·26
SO_3	·49
OH_2 on ignition	1·95
OH_2 driven off below 110°	·37
	100·43

differences there is such a close general resemblance between the rocks from these different localities, and the type of rock is such an unusual one, that there is reason to believe them to have been connected in their origin. Beyond the community of type and manner of occurrence there is at present no evidence to bring forward in support of this view, which is, therefore, to a large extent hypothetical. As to their relative ages there is not much evidence; the Sutherland pipes are younger than the Karroo dolerites, and therefore very probably younger than the Stormberg period, but how much so is an open question; the Spiegel River intrusion took place later than the deposition of the Uitenhage beds, or rather than that portion of them represented in Riversdale. The Stormberg beds may be considered as of upper Triassic (Rhaetic) age, and the Uitenhage beds are correlated with the Lower Cretaceous of Europe. If the supposition of a common origin of the Spiegel River and Sutherland pipes can be legitimately made, then the latter must also be considered as of later age than the Uitenhage period.

General Summary of the Relationship of the Volcanic Vents.

There is good reason to think that the peculiar pipes, filled with breccias of various kinds or with ultra-basic igneous rock, found at so many places within the Colony, near Pretoria, and in the Orange River Colony were produced at about the same time. Though the pipes at present known occur in groups far removed from one another, it is probable that many more have escaped detection, or have been found unprofitable by prospectors, and therefore have passed out of memory. The fragments of blackened wood discovered in the blue-ground at Kimberley probably came from trees growing near the vent at the time of the explosions, and are the only direct evidence of the area having been dry land at that time. By other arguments, however, we may be satisfied that the eruptions took place after the great fresh-water basin in which the Karroo formation was deposited became dry land. This event probably happened at the close of the Stormberg period, and there is no evidence of the deposition of any later beds, save gravel and alluvium, in the Karroo region. Whether the Uitenhage beds extended into this area is not known, but in any case it is not likely that they ever formed such thick bodies of rock there as they did south of the Zwartebergen. We may consider that since Stormberg times the great interior region of the Colony has remained above the level of the sea, and at some time during the long epoch that separates the present day from the Stormberg (Rhaetic) period, the terrific ex-

plosions took place that drilled holes only a few hundred feet in diameter through many thousands of feet of rock; these holes were finally filled up either with serpentinous breccia, a mixture of such matter and ultra-basic igneous rock, agglomerates and tuffs of little else than comminuted sedimentary beds, or with igneous rock alone as at Spiegel River and some of the Sutherland Commonage vents.

Whether the present surface section of a pipe is surrounded by Pre-Cape beds as at Pretoria and some of the West Griqualand occurrences, or by different stages of the Karroo formation as at Kimberley and Sutherland, depends entirely on the relative progress of denudation. In no case has the original crater been preserved. We are, indeed, entirely ignorant as to whether piles of agglomerates and tuffs were thrown out at the surface. Had lava streams of any great thickness issued from these volcanoes they would probably have left outliers to bear witness of their former extent, for the Stormberg lavas have a wide distribution, and they are older than the western volcanoes. It is of course quite possible that evidence bearing on these questions is still preserved in South Africa, but remains to be discovered.

Pipes of the nature of those described in this paper are not abundant in other parts of the world. At Bingara* in New South Wales there is a pipe of which the contents bear a striking general resemblance to those of some of the South African pipes. In a dull greenish blue matrix there lie fragments of claystone, melaphyre, augite-picrite, eclogite, and many minerals including pyroxenes, garnet, felspar, and pleonaste. The age of this vent is probably Tertiary.†

In North America, dyke rocks strikingly similar to the blue-ground of Kimberley have been met with at Syracuse, New York, and in Kentucky. They have a distinct fragmental structure, though formed of minerals that generally occur in ultra-basic igneous rocks, and although they occur in dykes.‡

In a paper dealing with the occurrence of eclogite boulders in the Newlands Mine Professor Bonney § takes the view that the rounded and apparently waterworn boulders of eclogite were obtained from a conglomerate—the Dwyka conglomerate—during the explosion which caused the pipe. This view cannot be maintained, at any rate the

* See G. W. Card, "An Eclogite-bearing Breccia from the Bingare Diamond Field," Rec. Geol. Surv. of New South Wales, vol. vii. pt. ii. 1902, pp. 29–39.

† "The Mineral Resources of New South Wales," E. F. Pittman, 1901, p. 393.

‡ The original descriptions of these rocks are not available to us, but a good account by Professor Bonney is printed in "Genesis and Matrix of the Diamond,' p. 58.

§ *Geol. Mag.*, 1899, p. 321

Dwyka conglomerate cannot have supplied the boulders. In the first place that conglomerate is thinner in the north of the Colony than elsewhere—at Kimberley, for instance, it is only a few feet in thickness; secondly, the conglomerate and its contents are fairly well known in Prieska and between Loeries Fontein and Willowmore, but eclogite is not known to occur in it, and it is unlikely that rocks of this nature should be so abundant at certain localities where vents happen to have been established; thirdly, rounded boulders of the ordinary coarse-grained ophitic olivine-dolerite of the Karroo type are abundant in the Balmoral pipe; these dolerites were evidently derived from the intrusive sheets and dykes that traverse the Beaufort beds of the Nieuweveld, and are not known to occur in the form of boulders in the Dwyka conglomerate, which is a much older rock than the intrusions. In the case of certain boulders noticed at Saltpetre Kop, the quartzites and granites, it is quite possible that their origin was similar to that advocated by Professor Bonney for the eclogite boulders, for quartzites and granites are extremely abundant in the Dwyka conglomerate throughout its extent, so far as it has been surveyed in Cape Colony; and in the Tanqua Karroo, due west of Saltpetre Kop, the conglomerate is probably some 800 feet thick, while directly south of the Kop, along the south of the Karroo, its thickness is still greater. The Dwyka conglomerate almost certainly underlies the Sutherland area, at a depth of perhaps 3,000 feet. The quartzite, however, is distinctly like that in the Table Mountain series, so the boulders may have been derived directly from that series which perhaps underlies the Saltpetre Kop area at a depth of at least 5,000 feet.

The great area of crystalline schists, gneiss, granite, and granulites of the north and north-west of the Colony is as yet very imperfectly known, but so far as the rocks have been examined they do not include granulitic masses of nearly such basic composition as the eclogites of the blue-ground; it is unlikely that the latter formed part of the old crystalline schists now exposed at the surface, for had they done so some out-crops would probably have been found of this remarkable type of rock, evidently of wide distribution deep under the surface.

ON TWO NEW THEROCEPHALIAN REPTILES (*GLANOSUCHUS MACROPS* AND *PRISTEROGNATHUS BAINI*).

By R. Broom, M.D., B.Sc., C.M.Z.S., Victoria College, Stellenbosch.

(Read March 30, 1904.)

(Plate VI.)

Glanosuchus macrops, g. n. et sp. n.

This new genus and species is founded on a fairly complete skull discovered by Mr. Snyman at Knoflok's Fontein, near Van der Byl's Kraal in the Gouph. It is the skull of a moderately large Therocephalian reptile with the teeth fairly well preserved and with the greater part of each mandible in position. The specimen has been subjected to a considerable degree of pressure, which has not only produced some distortion but has made the bone in some parts extremely brittle. In addition to this the bone, except in parts that are much weathered, is so like the matrix that in one or two regions one is unable to say with certainty what is bone and what matrix. It is thus impossible to give as complete a description of the skull as one should like, and in the figures of the skull I have been obliged to depart from my usual practice of only drawing what is bone.

The skull bears some little resemblance to one or two of the already known Therocephalians, especially Scylacosaurus, Scymnosaurus, Ælurosaurus, and Pristerognathus, but its dentition shows it to be distinct from any of those genera. From the occipital condyle to the front of the snout the skull measures almost exactly 12 inches, and the greatest width across the temporal arches has probably been about 6 inches. The snout is moderately long and powerfully developed, with the nostrils directed more forwards than outwards. The orbits are relatively rather small, and are situated behind the median transverse plane. The temporal fossæ, though imperfect, have probably extended back beyond the plane of the

occipital condyle. The dentition of the upper jaw is five large pointed incisors and a sixth small one, one large canine, and apparently five small simple molars.

The premaxillary is fairly well seen on both sides of the skull. It is a moderately strong bone, and passes up between the nasal and the maxillary. There is evidence of there having been a strong internasal process. Posteriorly the bone is overlapped as in other Therocephalians by the maxillary.

The nostrils are oval openings, looking forwards, outwards, and slightly upwards. Each is about $1\frac{1}{4}$ inch in length and about $\frac{1}{2}$ inch in depth.

The nasal bones are, as in other Therocephalians, remarkable for being broader in front than behind. They are not ancylosed as in Lycosuchus.

The maxillaries are well developed, but so far as displayed do not present any features of special interest.

The frontal region is very distinctly concave, both transversely and antero-posteriorly. In the antero-posterior direction the concavity, though not very deep, extends from the front of the frontal bone to near the parietal foramen.

The lachrymal, prefrontal, and postorbital bones are not sufficiently well preserved to admit of description.

The parietal region is about half the breadth of the frontal region. The parietal foramen is large.

The jugal appears to have been well developed.

The squamosal bone is almost entirely absent, but it must have been a larger bone than in Lycosuchus to accommodate the muscles of the lower jaw.

The occiput is very imperfect and not well displayed. The condyle is large and single, and bears considerable resemblance to that in Dicynodon. The upper part of the occiput (? supra-occipital) slopes slightly forwards.

The palate has only been slightly cleared of matrix, but it is manifest that it agrees pretty closely with that in Scylacosaurus. The pterygoids have large transverse processes which descend almost to the lower margins of the mandibles. Immediately in front of the line of the transverse processes there are situated a number of small, round, pointed teeth. The pterygoids posteriorly after lying side by side for a short distance pass outwards and backwards to meet the quadrates.

The dentition differs from that of any of the Therocephalians in which the full dentition is known. There are on each side five large pointed subequal incisors, each of which has a flattened and

finely serrated posterior border. Behind the fifth incisor is a small pointed tooth which I regard as a sixth incisor. The maxillary teeth comprise a single large canine and apparently five small pointed molars. The canine is somewhat flattened behind and has a finely serrated edge, but so far as preserved the anterior part of the tooth is smooth and rounded. The three anterior molars are fairly well preserved, and in the second and third at least both the anterior and posterior edges have fine serrations. The fourth molar appears to be lost and the fifth is very imperfect.

The mandible has the dentary bone relatively rather more largely developed than in Lycosuchus. A somewhat oblique section of the jaw near the plane of the posterior border of the orbits shows the dentary above resting on the surangular with the angular and what is apparently the splenial below.

The following are the principal measurements of the skull and teeth :—

Length of skull, snout to occipital condyle	315 mm.
Breadth of snout above canines	79
Estimated interorbital width	55
Estimated width in temporal region	145
Length 1st incisor–5th incisor inclusive	48
Height of 2nd incisor	24
Length from 5th i–front of c (upper part)	12
Length of canine	17·6
Length from c–front of m^1	16
Length m^1–m^5 inclusive	45·3
Length of m^2	6·5

Pristerognathus baini, n. sp.

This new species is founded on an imperfect snout of a small Therocephalian. It was obtained many years ago by Mr. T. Bain in the Western Karroo, but the exact locality is unknown. It was recently presented to the South African Museum by Mr. J. M. Bain together with a number of other interesting specimens collected at various times by Mr. T. Bain.

The specimen consists of the snout, broken off in the region of the canine teeth. It does not seem to present any character by which it can be distinguished generically from Pristerognathus of Seeley, but it is a distinct species from *P. polyodon* Seeley. As in that species, so in this, the dental formula is $\frac{i6}{i3}$.

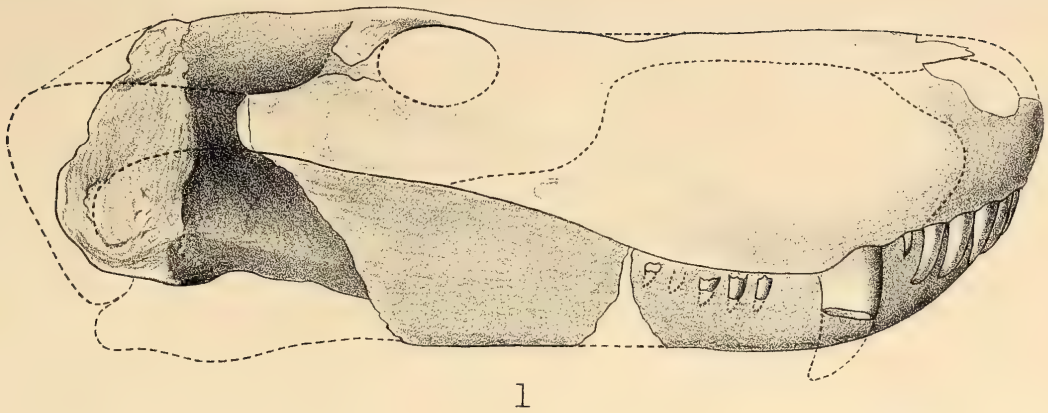
The following are the principal measurements :—

Length from i^1–i^3 inclusive	14·3 mm.
,, ,, i^4–i^6 ,, ...	14·6
,, of i^1	5
,, ,, i^2	5·2
,, ,, i^3	5·7
,, ,, i^4	6
,, ,, i^5	4·2
,, ,, i^6	3·2

REFERENCE TO PLATE.

FIG.

1. Side view of skull of *Glanosuchus macrops*, × ·31.
2. Upper ,, ,, ,, ,, × ·31.
3. Under ,, ,, ,, ,, × ·31.
4. Section of mandible of ,, ,, × ·4.
5. ,, ,, pterygoids of ,, ,, at plane A, fig. 3, × ·31.
6. ,, ,, ,, ,, ,, ,, ,, B, fig. 3, × ·31.
7. Side view of snout of *Pristerognathus baini*, nat. size.
8. Under ,, ,, ,, ,, nat. size.



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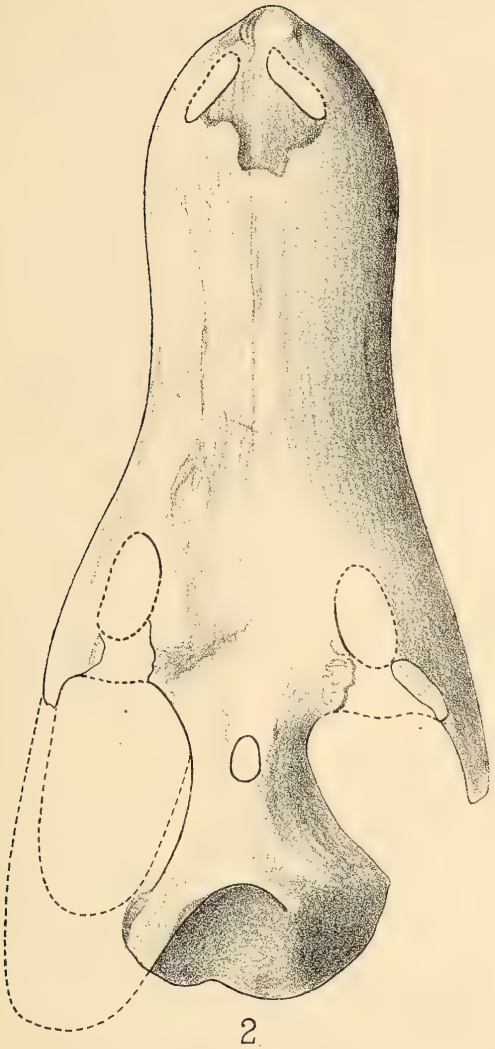

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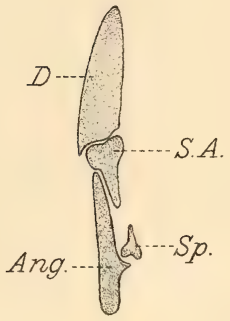

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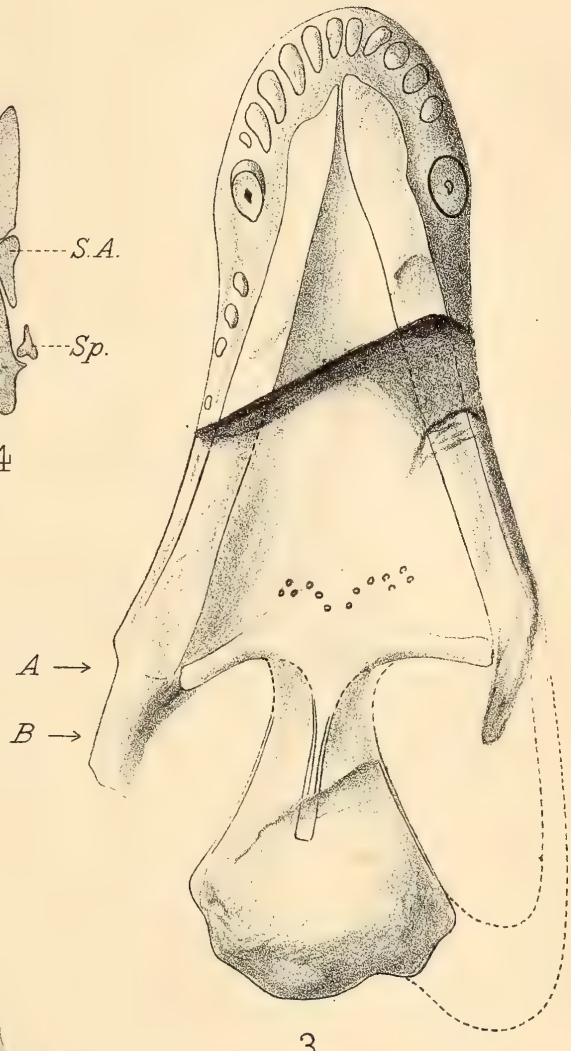

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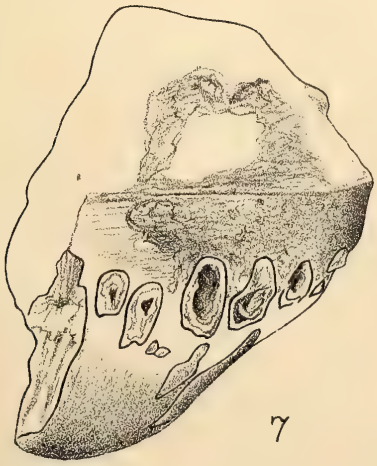

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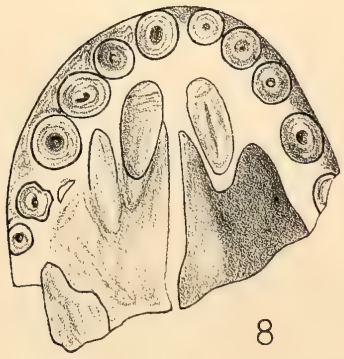

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R. Broom del.

West, Newman lith. London.

Fig. 1-6 GLANOSUCHUS MACROPS, *Broom.*
Fig. 7-8 PRISTEROGNATHUS BAINI, *Broom.*

THE ORIGIN OF THE MAMMALIAN CARPUS AND TARSUS.

By R. Broom, M.D., B.Sc., C.M.Z.S., Victoria College, Stellenbosch.

(Read May 25, 1904.)

(Plate VII.)

Few problems in biology are of greater interest than that of the origin of mammals, and within the last thirty years much discussion has been given to the problem. The majority of embryologists, from the consideration of certain developmental conditions, have been led to the conclusion that the mammals have been descended from some Batrachian ancestor or some even more primitive form which may have lived in Devonian times. Most palæontologists, on the other hand, have considered that in the Theriodont and Dicynodont reptiles we have forms which are so strikingly mammal-like that the ancestral mammal should be looked for either in one of these groups or in some closely allied order. As recent investigations point pretty conclusively to the fact of the mammalian skull being directly descended from that of the Theriodont, it becomes important to see if the evidence derived from other parts of the skeleton confirms that given by the skull. Already the shoulder girdle of the Anomodont has been shown to be essentially similar to that of the Monotreme (1), while that of the Monotreme resembles closely that of the fœtal Marsupial (2). In the present paper I hope to show that the evidence derived from the study of the carpus and tarsus confirms that of the skull and shoulder girdle. Unfortunately the carpi and tarsi of the fossil reptiles are much less perfectly known than most other parts of the skeleton, since unless the various elements are found in undisturbed position the evidence derived from them is not of a very satisfactory nature. Still it is possible even at present to show from the few well-preserved specimens known that the mammals must have been derived from some Synapsidan reptile,

In the Stegocephalia the carpus is usually but imperfectly ossified. In Eryops, however, it is well ossified, and fortunately a well-preserved specimen is known (3). As preserved there are four bones in the proximal row, five in the distal, and two other elements in the centre. By Cope the four proximal bones are believed to be Radiale, Centrale, Intermedium, and Ulnare. By Emery (4) they are looked upon as the Radiale, Paracentrale, Intermedium, and Ulnare. While it is difficult for one who has only the figures to go by to give a very decided opinion, I should like to suggest that the four proximal elements are probably homologous with the four proximal elements found in the carpi of most primitive reptiles and well seen in Sphenodon, viz., Radiale, Intermedium, Ulnare, and Pisiform. The two central elements are undoubtedly centralia 1 and 2, while the five distal elements are as certainly carpalia 1–5. The carpus of Eryops would thus seem to agree closely with that of Sphenodon, and no doubt represents a slight specialisation of the primitive form from which the carpi of all the higher animals have been derived.

It is probable that in early Permian or late Carboniferous times some member of the Stegocephalia gave rise to the Cotylosauria. This order, though of the greatest interest as containing most probably the ancestors of all the later reptiles, both of the Synapsidan and Diapsidan groups, is at present only imperfectly known. An imperfect carpus of Pariotichus has been described (5), but as the elements were not found in position it is difficult to place much reliance on it. The carpus in Pareiasaurus has not been described, but Huene (6) has recently figured the fairly well-preserved carpus of the allied genus Sclerosaurus. In his Taf. I. he indicates four elements as carpalia 1–4, and this identification seems probably correct. Proximal to C 3 and C 4, and situated immediately distal to the Ulna, is another element, almost certainly the Ulnare. In Taf. II. what is evidently the counterpart of this Ulnare is marked "Pisiform," and a more proximal bone is marked "Ulnare." What is regarded as Ulnare in Taf. II. seems to me to be a portion of the Ulna. The element between the Radius and Ulna, and which Huene regards as the Radiale, I should incline to regard as the Intermedium. The element marked C 3 in Taf. II. does not appear to be the same as C 3 in Taf. I., and is in my opinion the centrale. It is thus probable that the Cotylosaurian carpus consisted of four proximal elements, a centrale, and four distal elements. While the specimen of Sclerosaurus practically proves these elements to have been present, it does not disprove the presence of a second centrale, and as many of the descendants of the Cotylosaurus retain two

centralia, we may conclude that two centralia existed in the Cotylosaurian carpus.

In Procolophon (7, 8, 9), the Diaptosaurian, most nearly related to the Cotylosaurs, the carpus is fortunately well known. Proximally there are a well-developed pisiform, a large ulnare, and a fair-sized narrow intermedium. The radiale appears to have been cartilaginous. In the centre of the carpus are two centralia, and distally there are four carpalia. If the radiale is rightly regarded as having been cartilaginous, then the carpus would appear to have agreed with that of Eryops as regards the elements except that in Procolophon the carpale 5 is absent or cartilaginous.

The structure of the skull renders it probable that the Therocephalians are the direct descendants of the Cotylosaurs in the line which gave rise to the Mammalia. Of the Therocephalians the only carpus known is that of Theriodesmus (10). Fortunately the specimen is well preserved and the degree of displacement of the bones so slight that there can be little doubt as to the interpretation of the various elements. Bardeleben (11) has recently redescribed and figured the carpus. He has shown that there are four bones in the proximal row—radiale, intermedium, ulnare, and pisiform—two centralia and four carpalia. The figure of the carpus which I give is only a slight modification of that given by Bardeleben.

Among the Dicynodonts the carpus is pretty well known. In most genera it is well ossified, but in the aquatic Lystrosaurus it is mainly cartilaginous. The only Endothiodont carpus known is that of *Opisthoctenodon agilis*, but fortunately this is known by a fairly satisfactory specimen. As in most primitive reptiles, the proximal row consists of four bones—a broad short radiale, a small intermedium, a large ulnare, and a rather small pisiform. In the centre of the carpus are two broad centralia. The distal row is formed of a large carpale 1, small carpalia 2 and 3, and a large carpale 4. On the radial side of the carpus as preserved are three small bones, which may belong to the hand, but as the specimen is of very small size and crushed in on the base of the skull, it is impossible to be quite certain of the nature of the fragments. I have figured them as they occur. The two bones adjoining the first carpale and first metacarpal are probably the bones of a prepollex, as in Theriodesmus. The third little bone possibly does not belong to the manus.

The carpus of Oudenodon (12) I have already elsewhere described. It closely resembles that of Opisthoctenodon, but there appears to be no trace of a prepollex. The proximal row consists of radiale, intermedium, ulnare, and pisiform. There are two centralia, and apparently five carpalia. It is doubtful if the fifth carpale is really

distinct from the fourth, but there is some evidence of its having been distinct. In my previous description of this carpus I mistook the first carpale for the first metacarpal.

It is unfortunate that in the Theriodontia the group from which the mammals appear to have directly sprung, only one carpus is at present known, and that an imperfect one. This is the carpus of *Microgomphodon eumerus* (13) described and figured by Seeley. Seeley considers there are three bones in the proximal row, but as it is very probable that the large element with which the ulna articulates is not the pisiform as Seeley believes, but the ulnare, and that the pisiform is missing, it seems likely that the proximal row in the Theriodonts has four bones, as in the more primitive groups and the majority of mammals. There appears to be only one centrale, and only four carpalia. It is possible, however, that the element between the radiale and the ulnare is not the intermedium, but a second centrale, and that the intermedium is not seen in the specimen. The arrangement of the bones in the Endothiodont carpus suggests this possibility. It is impossible to decide the point by the figure.

The examination of the series of carpi shows that there has been very little evolution in the carpus from the higher Labyrinthodonts to the Theriodonts. The fifth carpale becomes lost, but otherwise any of the carpi from the Cotylosaurians to the Theriodonts might be the one from which the mammalian type has been derived.

The stages in the evolution of the tarsus, though they are less fully known than the stages of the carpus, throw much more light on the line of descent of the mammals.

The Labyrinthodont tarsus is practically unknown. The tarsus of the primitive Stegocephalian Archegosaurus is known, but there is some difference of opinion as to its interpretation. Its most interesting feature is that it consists of at least nine distinct elements, and certain of these may represent the fusion of two. But while the Stegocephalian tarsus contains so many distinct elements, the number is found to be very considerably reduced in all the descendants. In some the reduction appears to be due to a number of the elements uniting together; in others the reduction is evidently due to some of the original elements being lost.

In the Cotylosauria the tarsus is very imperfectly known. In Pareiasaurus and Sclerosaurus there is a large tarsal bone probably made up of the united tibiale, intermedium, and fibulare. The other elements have possibly been cartilaginous. Case has figured a fairly satisfactory tarsus of Pariotichus (5). It shows that the proximal tarsal row consists of two distinct bones—either tibiale and fibulare, or with possibly an intermedium united to one of the other

two elements. There are probably five tarsalia and a distinct centrale.

In Procolophon (7) the tarsus consists of six bones, but the intermedium is manifestly united with the tibiale, and it is not improbable that the centrale is united with the fibulare. There are only four tarsalia ossified. In other primitive Diaptosaurians five tarsalia are ossified.

In Sphenodon (14) the structure and development of the tarsus have been very fully worked out by Howes and Swinnerton; and though Sphenodon has advanced far from the point of separation of the Diapsida and the Synapsida, it gives us perhaps a better idea of the primitive type of the Reptilian tarsus than we get from most of the fossil specimens. Here we find that the tarsus in its early development consists of a moderate-sized fibulare and tibiale, a large intermedium, a rather small centrale, and four tarsalia.

Unfortunately no Therocephalian tarsus is known, so that the intermediate stages between the Cotylosaurian types and the Dicynodont are at present hypothetical.

The Dicynodont type is fortunately now fully known. A few years ago I described the tarsus of Oudenodon (12), and since then have had the opportunity of examining two other Dicynodont tarsi. The tarsus of *Oudenodon trigoniceps* has been somewhat more fully developed, and a slight modification is required of my previous description. The small element which I regarded as the centrale has been found to be really a part of the tibial. The intermedium, however, seems to be a distinct element. The first row of the tarsus thus consists of a large semicircular tibiale, and a somewhat larger fibulare, with a small intermedium fitted in between them. The distal row is formed of four bones, of which the first is large and almost like a metatarsal. Between the tibiale and the first tarsale there is a moderate-sized gap in which it is moderately certain there was a cartilaginous centrale. The second Dicynodont tarsus I have examined probably also belongs to a species of Oudenodon, and while it agrees closely with that of *O. trigoniceps* it shows a distinct ossified centrale between the tibiale and first tarsale. The centrale is not fully ossified like the other elements, but has the appearance of an imperfectly ossified cartilaginous element. The third tarsus is a specimen in the Albany Museum—probably belonging to a species of Dicynodon. Here the most noteworthy feature is the presence of a large fully ossified centrale, which articulates with the tibiale and with probably all four tarsalia. The Dicynodont tarsus, with the exception of having a distinct intermedium, is thus seen to be practically of the mammalian type.

Only one Theriodont tarsus is known—that of Microgomphodon (13)—and unfortunately it is not satisfactorily preserved. It agrees, however, with the Dicynodont tarsus in having the tibiale and fibulare of large size. According to Seeley the calcaneum (=fibulare) "does not develop a posterior heel process." As, however, only the anterior or upper surface of the tarsus seems to be displayed, it is difficult to see what evidence there is for this statement. In the Dicynodont fibulare there is a distinct heel process, and it is highly probable that one also exists in the Theriodonts. There is in the tarsus of Microgomphodon a wide space between the tibiale and the first tarsale, so that the condition of the Theriodont tarsus is probably very similar to that in the Dicynodont, there being evidently either a cartilaginous centrale or a bony centrale which is lost from the specimen.

While the mammalian carpus has become very slightly specialised, and is hence of little service in guiding us to the mammalian ancestor, the specialisation of the tarsus is so peculiar that all claimants to the honour of being the immediate forefathers of the mammals may be dismissed if they do not show some approximation to a similar specialisation. We may thus put on one side all modern types of reptiles and all the Amphibia, none of which can have any claim to be the immediate mammalian ancestor, and we have left the Cotylosaurians, some of the primitive Diaptosaurians, the Therocephalians, and the Dicynodonts and Theriodonts. In these latter we find more or less approximation to the mammalian type, but if we take into consideration the extreme mammalian specialisation—the presence of a large tibiale and fibulare with a centrale which is not in the centre but comes between the tibiale and the first tarsale—then we are driven to the conclusion that the mammalian ancestor must have been a Dicynodont, a Theriodont, or a form belonging to a closely allied order. From the examination of the skull we have good reason to believe that the ancestor was a Theriodont, and the evidence of the tarsus fully confirms that derived from the skull and other parts of the skeleton, and the carpus, while it does not add any very strong evidence, certainly does not afford any evidence that is not also in harmony with this conclusion.

Addendum (Oct. 20, 1904):—Case has recently published a short paper "On the Structure of the Fore Foot of Dimetrodon" (Journ. Geol., vol. xii., No. 4, May–June, 1904), in which he figures an almost perfect carpus, and shows that it is strikingly like the carpus of Procolophon. The only differences of importance are that in Dimetrodon the radiale is large and fully ossified, and that there is a distinct ossified fifth carpale.—R.B.

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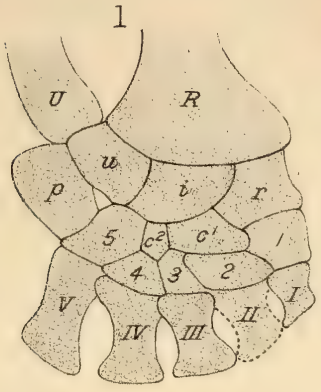
Fig.

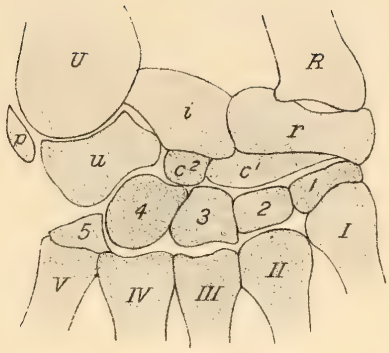
1. Carpus of Eryops. After Emery. Slightly modified. Reduced.
2. Carpus of Sphenodon, juv. After Howes and Swinnerton. Enlarged.
3. Carpus of Procolophon. Slightly enlarged.
4. Carpus of Theriodesmus. Arrangement restored.
5. Carpus of *Opisthoctenodon agilis*. Enlarged.
6. Carpus of *Oudenodon trigoniceps*. Slightly enlarged.
7. Tarsus of Procolophon. Slightly enlarged.
8. Tarsus of *Oudenodon trigoniceps*. Slightly enlarged.

1



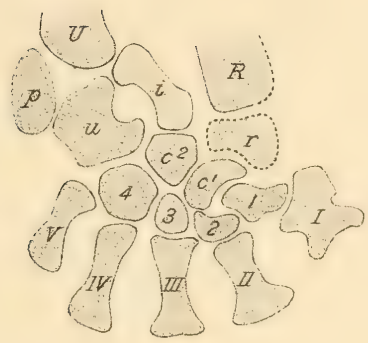
CARPUS OF ERYOPS

2



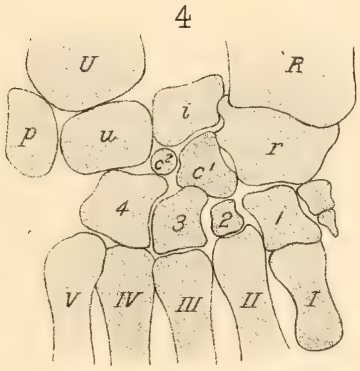
CARPUS OF SPHENODON

3



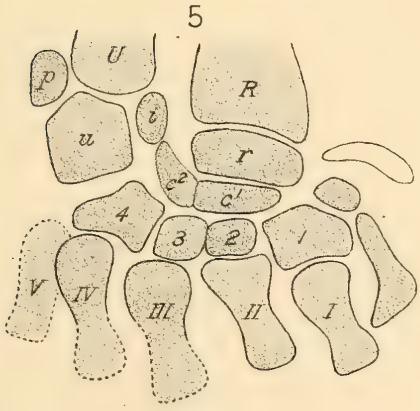
CARPUS OF PROCOLOPHON

4



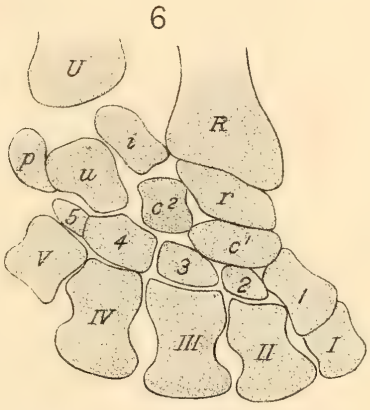
CARPUS OF THERIODESMUS

5



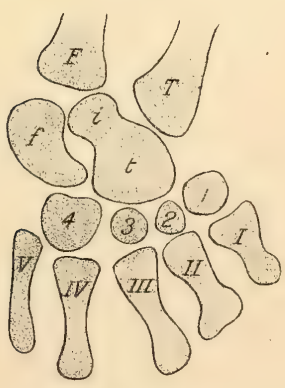
CARPUS OF OPISTHOCTENODON

6



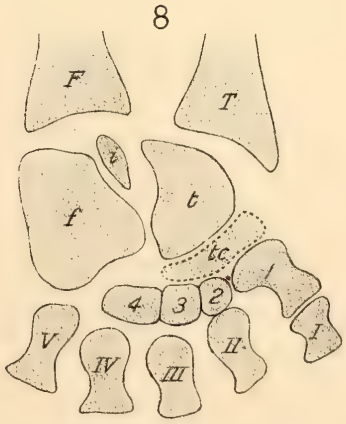
CARPUS OF OUDENODON

7



TARSUS OF PROCOLOPHON

8



TARSUS OF OUDENODON

R. Broom del.

West, Newman lith. London.

REPTILIAN CARPI AND TARSI

MIMICRY AMONG PLANTS.

By R. Marloth, Ph.D., M.A.

(Plate VIII.)

(Read May 25, 1904.)

Mimicry among animals is of such general occurrence that nobody who takes the slightest notice of the creatures around him can overlook these means of protection. Especially numerous are cases of mimicry among insects, and South Africa in particular possesses many most remarkable forms of this kind.

Whoever meets the "flying leaf" or the "walking twig" or other members of the Mantis tribe in their natural surroundings cannot help admiring the perfect similarity of these insects and of the plants among which they live.

But there is no need for me to mention any further cases of mimicry among insects, for the subject has been dealt with in an excellent way in the presidential address delivered by Mr. Trimen in 1884.

Quite different, however, is the state of our knowledge with regard to the occurrence of mimicry among plants. I may state from the outset, that many of the instances described as mimicry of plants appear to me to be due to teleological speculations and the imagination of the writers. One of the most common cases of this kind is that of the white dead nettle, which is supposed to mimic in its foliage the stinging nettle. In all probability the popular names of the two plants have had something to do with the view that the dead nettle should find some protection in this similarity of foliage. I think that this similarity is a mere coincidence, just as the fruit of the edible chestnut, when green, resembles that of the horse-chestnut; yet I am not sure that the similarity of the two fruits has not induced some writer to proclaim this as another case of mimicry.

There are, on the other hand, a number of instances in which the similarity of parts of plants to other objects is so striking that one can hardly doubt that they have been acquired by natural selection. The best examples of this kind are offered by some orchids, not only among the gorgeous tropical species, but also by some which are fairly common in various parts of Europe. Several species of the genus *Ophrys* do not bear their names without justification, for the flowers of *O. apifera*, *muscifera*, and *aranifera* resemble bees, flies, and spiders to such an extent that they may be easily mistaken for them without closer examination. Of course such similarities are not cases of protective colouring, for the function of these remarkable forms and colours is evidently connected with the fertilisation of the flowers. In all probability they afford the insects which visit the flowers a certain amount of safety from their enemies by hiding them during the time the visitors spend there.

Another example of this kind of mimicry is afforded by some Stapelias, a group of succulent plants which has its headquarters in South Africa. The flowers of most species of this group emit a strong odour resembling that of putrid meat, thereby attracting carrion flies which effect cross-fertilisation. It is even said that the eggs and larvæ of such flies have been observed on these flowers, which would show that the deception had been complete. That the scent must be very deceptive to animals I know from experience. I had a rare *Stapelia* in my garden which was going to flower for the first time, but one day I found the bud scratched to pieces by my dog.

All these instances, however, are not mimicry in its proper sense, for the resemblance does not afford any protection to the plant. But there are a few examples recorded where this seems to be really the case. Sp. M. Moore* mentions as one of the means of protection which some desert plants of Australia possess, the similarity of the foliage of some species of *Loranthus* with the leaves of the host upon which they grow. He avoids the word mimicry and introduces instead the term "homoplasy." In particular are mentioned *Loranthus pendulus* Sieb, and *L. Quandang* Ldl., which, owing to this close resemblance, can hardly be discovered on the trees or shrubs upon which they grow. He also mentions that camels are very fond of the *Loranthus* but do not eat the leaves of the host. That, of course, does not prove much, for camels are not indigenous to Australia. The only inference which one could draw from this observation would be the supposition that other

* Sp. M. Moore, "The Botanical Results of a Journey into the Interior of Western Australia," Journ. Linn. Soc., xxxiv., 1899.

herbivorous animals may have the same taste and that in all probability the parasitic plant would thus escape their attacks.

The other example of apparently real mimicry is described by Burchell nearly one hundred years ago. In his travels through the karroo he found a species of Mesembrianthemum, which he named *M. turbiniforme*, thinking it to be undescribed. As a matter of fact it had been found by Thunberg, who had named it *M. truncatum*, from the shape of its leaves. Burchell * gives the following account of his find: "On picking up from the stony ground what was supposed a curiously shaped pebble it proved to be a plant, and an additional new species to the numerous tribe of Mesembrianthemum; but in colour and appearance bore the closest resemblance to the stones between which it was growing. On the same ground was found a species of the Gryllus tribe amongst the stones, and so exactly like them in colour and even in shape, that it could never have been discovered had it not been observed just at a moment when in motion. The intention of Nature, in these instances, seems to have been the same as when she gave to the Chameleon the power of accommodating its colour, in a certain degree, to that of the object nearest to it, in order to compensate for the deficiency of its locomotive powers. By their form and colour, these insects may pass unobserved by those birds, which would soon extirpate a species so little able to elude its pursuers, and this little Mesembrianthemum may generally escape the notice of cattle and wild animals."

This plant has been referred to by Wallace † as the stone Mesembrianthemum of the karroo, and its case is mentioned as the only example of real mimicry that has come to his notice.

As stated at the beginning of my paper, I was at first very sceptical about this and similar statements, particularly as cattle, which Burchell mentions, are not indigenous to the country. Gradually, however, my observations of such cases have become more numerous, hence I cannot look upon them all as mere coincidences.

The most remarkable plant in this respect is *Mesembrianthemum Bolusii*, Hook. f., which inhabits the hills of the karroo about Aberdeen. It generally produces only two leaves, which grow to the size of a duck's egg. Their surface is rough like weathered stone and their colour a brownish grey with a touch of dull green. The leaves are half buried in the soil or between the stones among which the plants grow, hence it requires a keen eye to detect them

* Burchell, "Travels in the Interior of Southern Africa," London, 1822, vol. i. p. 310.

† Wallace, A. R., "Tropical Nature and Other Essays," London, 1878, p. 223.

when not in flower. In autumn, however, when bright yellow flowers about 2 inches in diameter appear between the leaves, the plants are very showy. But that does not last long, and during the dry season the leaves look just like lumps of stone. [See Plate VIII.]

A similar colour and texture of surface have the leaves of *Mesembrianthemum nobile* Haw., which is fairly common in the karroo, *e.g.*, near Laingsburg and Fraserburg Road.

In the Bokkeveld karroo, between Ceres and Calvinia, occurs a species of Mesembrianthemum with small leaves, the colour of which harmonises with the pebbles and gravel among which they are half buried to such an extent that I detected them only while stooping down, although the surface of the ground was quite bare. The most curious feature of the case was that the plants differed in colour, some being more yellowish, leather coloured, and others more brown, rust-coloured, and that these variations coincided with the yellowish or brownish colour of the shaly gravel. I could not help thinking of Burchell's reference to the chameleon, although I am unable to understand how this apparent adaptation might have come about. To make the analogy even more complete I captured a member of the Gryllus tribe—I cannot say a grasshopper, for there was no grass within miles, nor did the insect bear the slightest resemblance to grass—which, when at rest, looked so exactly like a brown pebble that I took a few of these fragments of stone with me.

There are several other species of Mesembrianthemum which are so curiously marked that in their original locality they easily escape the notice of men and animals. An instance of this kind was mentioned privately by Mr. Hammond Tooke. During a stay in the karroo he had often used a certain footpath which passed for some distance over bare ground merely covered with pebbles. One day, however, he saw some of these pebbles bearing bright yellow flowers, one at the top of each stonelet. The number of these flowering pebbles increased every day until there were hundreds of them on the otherwise bare veld. It was *Mesembrianthemum truncatellum* Haw., which occurred rather plentifully in this locality.

It may be asked whether these plants have any enemies against which this protection would be useful. On that point observation leaves no doubt, for goats eat all these species readily, hence it may be assumed that the wild antelopes do the same. Ostriches are also very fond of them and hares and tortoises eat them as well. As some of these animals feed only or mostly at night time it is obvious that plants which are so well hidden have more chance of escaping destruction than others which can be more easily seen.

Another species of *Mesembrianthemum* seems to achieve the same object in a different way. It forms fleshy cushions on the ground up to 10 inches in diameter. These cushions consist of a large number of tooth-shaped fleshy leaves, which are snow white. All that is nothing unusual in the karroo, where plants with pure white leaves are not uncommon. It surprised me, however, that this plant occurred only where the ground was covered with fragments of white quartz. I found several patches of the plant, but only on these fields of white quartz. Of course there were many such localities without this plant, for white quartzites are of common occurrence in the Laingsburg and Ladismith districts.

A similar observation has been made in connection with another plant by myself as well as by a friend of mine. This is *Anacampseros papyracea* E. Mey., a little succulent of the karroo which is pure white owing to the large papery stipules which cover the tiny leaves. I have seen hundreds of these plantlets in the Laingsburg, Ladismith, and Prince Albert districts, but only on such fields of white quartz—with one exception, and that was a specimen growing in clayey soil. But, and this fact is very significant, this plant stood in a group of *Apicra deltoidea* Bak., which has leaves that are as rigid and sharp-pointed as if they were cut out of a piece of stout metal.

I do not consider the peculiar occurrence of this Anacampseros and the last-mentioned species of Mesembrianthemum as mimicry, for the white hairs on the leaves of the Mesembrianthemum and the papery stipules of the Anacampseros serve in the first instance another function. But the whiteness of the plants has probably allowed those individuals which occurred in similar surroundings to escape the depredations of animals, particularly of those which feed at night-time like the hares. It is interesting to note that some natives call this Anacampseros "haasjes kost," probably indicating that hares are fond of the plant.

In conclusion, I should like to sum up my views on this question, as far as the South African plants are concerned, as follows :—

1. There are some plants which seem to occur only, or at least mostly, on fields of white quartz, where they are not easily noticed, particularly not at night-time, owing to their own white colour. It is probable that this limited occurrence in these districts is due to the destruction of those individuals which sprang up in other localities where their whiteness easily betrayed them to the night-feeding animals. Examples are *Anacampseros papyracea* and a species of *Mesembrianthemum*.

2. There are some species of Mesembrianthemum which are so

well hidden among the fragments of yellow and brown shale that they are most difficult to detect. Yet this is also not true mimicry, for if these plants are cultivated in a moister climate, *e.g.*, at Capetown, they produce green leaves. This shows that the yellow and brown colourings were the effect of the karroo climate and not acquired protective adaptations, although the plants do obtain efficient protection from them in their natural surroundings.

3. There are, however, some species of *Mesembrianthemum*, viz., *M. bolusii* and *M. nobile*, which retain their remarkable surface structure even in cultivation, although the leaves become somewhat less dull under these modified conditions and lose consequently something of their desert character. This, I think, may be mimicry, or if one prefers the word, homoplasy.

It is possible that *M. truncatum* Thunb. and *M. truncatellum* Haw. are some more examples of this group.

MESEMBRYANTHEMUM BOLUSII, *Hook. f.* (*nat. size*).

R. Marloth: Mimicry among Plants.

Photo. A. Fuller. West, Newman, London, proc.

OBSERVATIONS ON THE STRUCTURE OF *MESOSAURUS*.

By R. Broom, M.D., B.Sc., C.M.Z.S.

(Read June 29, 1904.)

Plate IX.

The genus *Mesosaurus* was founded by Gervais in 1865 for a small fossil reptile found in Griqualand West, South Africa. The type specimen, which is now in Paris, consists of the head, neck, the two fore limbs, and the greater part of the body, and has been named *Mesosaurus tenuidens*.

In 1889 Gürich described, under the name *Ditrochosaurus capensis*, the remains of reptile closely resembling *Mesosaurus*, from near Hopetown. The remains are evidently those of an immature animal, and there seems little doubt that they are those of a young *Mesosaurus*.

In 1892 Seeley described a number of imperfect remains of *Mesosaurus* in the British Museum, and also the very fine specimen belonging to the South African Museum. The Cape Town specimen he regarded as belonging to the type species, but the British Museum specimens he referred to a new species, *M. pleurogaster*. From these specimens he was able to add much to our knowledge of the genus. The Cape Town specimen shows the neck, dorsal vertebræ and ribs, and the fore limbs in an almost perfect state of preservation, and less satisfactorily the shoulder girdle, which is considerably crushed and displaced. The London specimens reveal something of the structure of the abdominal ribs, and one of them shows the structure of the hind foot.

Though no further specimens of *Mesosaurus* have been described, a considerable number of specimens of the closely allied South American genus *Stereosternum* have been described, and almost

everything of its osteology is now known except the structure of the skull and the shoulder girdle.

A very fine specimen of a moderately large *Mesosaurus* has recently been discovered in Bushmanland by the Rev. C. A. Neethling, of Nieuwoudtville, and Mr. Neethling has been good enough to forward the specimen to me for examination.

This specimen consists of the greater part of the thoracic and abdominal regions, both hind limbs, and a very considerable part of the tail of a moderate-sized individual. Unfortunately the matrix is an exceedingly soft shale, and the specimen has been considerably weathered, especially in the thoracic region and the posterior part of the tail. The pelvis and both feet are well preserved, and there is the impression of a portion of the skull.

Owing to crushing it is difficult to make very much of the impression of the skull bones. They appear to me to represent the right maxillary bone, parts of both premaxillaries, the nasals, and in a much less satisfactory condition some of the bones in the orbital region. The premaxillaries, as in many other reptiles with long snouts, form a large part of the rostrum, probably as much as two-thirds of the upper surface between the point of the snout and the region of the orbits. Here they meet what are apparently the nasals. The maxillary is long and appears to extend backwards below the orbit. The nostril appears to be between the nasal, the maxillary, and the premaxillary bones. The other bones are not sufficiently well preserved to admit of description.

The impressions of 16 presacral vertebræ can be counted, but most of them are badly weathered. A few, however, show the structure of the under surface fairly satisfactorily. So far as can be made out, they agree closely with those of the Cape Town specimen. The ridge for the articulation of the rib runs from the small transverse process inwards and slightly forwards to the upper and outer corner of the cupped articular surface. On the left side 16 presacral ribs are seen in almost natural position, and two others much displaced. On the right side 15 ribs can be counted. A small, very imperfect impression may be the inner part of the right humerus, but this is very doubtful. In the case of the last two presacral vertebræ the ribs are not attached as in the more anterior vertebræ. In the last vertebra the short rib is attached to the transverse process, and in the second last the rib appears to be attached immediately below the transverse process.

The sacrum consists, as in *Stereosternum*, of two vertebræ, but their structure is not very satisfactorily shown.

Of the pelvis, the pubis and ischium of each side are fairly well

preserved; and on the left side a small part of the displaced ilium is seen. The pubis and ischium are flat bones which bear considerable resemblance to those of *Stereosternum*. The pubis of *Mesosaurus* differs from that of *Stereosternum* in that the pubic foramen is here closed externally by cartilage and not by bone, as the American genus. The ischium differs in having the external border less concave than in *Stereosternum*. The ilium is too imperfect to admit of description.

Each femur is well preserved, and is present as a slightly curved rod of bone with each end abruptly truncated. It is thus evident that each end of the bone was largely cartilaginous in life. The inner end is slightly thicker than the outer.

The cast of the left tibia is nearly perfect, and shows the bone to have been an almost straight rod, slightly constricted in the middle and a little thicker at the upper than the lower end.

In the case of both fibulæ the casts are imperfect at the proximal ends. The fibula appears to have been rather stouter than the tibia, and slightly curved—the concavity being directed towards the tibia.

The tarsus is represented by fairly satisfactory casts on each side. It consists of two large bones in the proximal row and four in the distal. Of the two proximal bones, the larger is probably the anchylosed intermedium and tibiale, and the smaller the fibulare. Between the two bones there is a fairly large foramen. The first, second, and third tarsalia are well preserved, and are small rounded bones of about equal size. The fourth is not very well preserved, but appears to be similar to the others. I can find no trace of a fifth tarsale. Possibly it existed as a cartilaginous element.

The impressions of all the digits are practically perfect. The first has a rather stout metatarsal and two short phalanges—the two phalanges being together shorter than the metatarsal. The terminal phalanx does not appear to have been clawed, though the evidence on this point is not quite conclusive. The second digit is considerably longer than the first. The metatarsal is narrower and of more uniform thickness. There are three phalanges which together are about equal in length to the metatarsal. In the third digit the metatarsal and first phalanx are each distinctly longer than in the second toe. There are four phalanges. The fourth and fifth toes are about equal in length and each considerably longer than the third toe. In the fourth toe there are five phalanges, each of which is, like the phalanges of the first three toes, moderately robust. In the fifth toe there are four phalanges, which are each distinctly more slender than those of the other toes.

The first three caudal vertebræ have each fairly long pointed ribs. Those of the first two are directed outwards; that of the third curves slightly backwards. In the fourth caudal the ribs are slightly shorter, but also curve slightly backwards. In the case of this vertebra there is an appearance suggestive of an intercentrum, but the evidence is not very satisfactory. From the fifth to the ninth vertebræ the caudal ribs steadily decrease in size. The ribs of the fifth and sixth vertebræ are directed outwards; those of the seventh, eighth, and ninth point slightly forwards. The sixth vertebra shows facets for a chevron bone. The tenth, eleventh, and twelfth vertebræ are too imperfectly preserved to admit of description. From the thirteenth to the twentieth the vertebræ are represented by imperfect casts of the right sides. These vertebræ agree fairly closely one with the other. They have large arches and spinous processes, and are remarkable for having well-marked splitting planes. One chevron is seen in almost perfect condition, and is strikingly like the chevrons of *Stereosternum*. The side view of the seventeenth caudal vertebra is shown in fig. 6. A restoration of the lower surface of the pelvis is given in fig. 4, while fig. 5 shows a restoration of the tarsus and metatarsus and phalanges.

From immediately in front of the pelvis to near the anterior end of the specimen there are the impressions of a very large number of delicate abdominal ribs. These are so slender that with the crushing each appears to have been broken into many fragments. It is seen that there has been a median series with on each side certainly two and possibly, but not probably, three lateral series. There would appear to have been about four sets of splints to each vertebra. The riblets are much more slender than those figured by Seeley in *M. pleurogaster*.

With regard to the species of this specimen, it is at present impossible to speak with certainty. So far as the vertebræ and ribs are concerned I fail to detect any differences of importance between it and the Cape Town specimen. If Seeley is correct in regarding the Cape Town specimen as belonging to the type species, then this specimen is probably also *Mesosaurus tenuidens*.

Notes on the Cape Town Specimen.

This specimen has already been fully described by Prof. Seeley, and a satisfactory figure has been given. There are still, however, one or two points on which further observations may not be superfluous.

The head is represented by the impression of the under surface.

The impression formed by the mandible is sufficiently satisfactory to enable one to make out the dentary, splenial, and angular bones. Of the palate the impression is much less satisfactory. Seeley speaks of the palate as being "completely closed," and considers it as "possible that the palato-nares may be in the depression behind the posterior divergence of the pterygoid bones." The only palatal bones of which there are any impressions in the specimen are no doubt the pterygoids as Seeley recognised. But so far as shown in the impression they are thoroughly Rhynchocephalian in type, though greatly elongated, and there seems to be no good reason for regarding the internal nares as being situated behind them.

In the basisphenoid region the elements are hopelessly crushed and displaced.

The cervical ribs are apparently all single-headed.

The shoulder girdle is fairly well preserved, but it is crushed and evidently considerably displaced. As the girdle is unlike that of any other known animal, it is impossible to speak with any degree of confidence of the original condition of the elements. In the specimen there are two fan-shaped portions of the girdle which approach each other in the middle line. These are regarded by Seeley as portions of the coracoids, the rest of the coracoids being directed outwards and backwards. The portion which is directed forwards and outwards beyond the foramen is believed to be the scapula. In fig. 2 I have attempted a restoration of the girdle. The fan-shaped part I believe to be the precoracoid, the posterior part the coracoid, and the anterior the scapula. In the specimen I consider both arches have been displaced by the coracoids having been drawn outwards. Although I have been unable to find any sutures, indications seem to be given of the different elements by the radiations of the bony fibres. In front of the cartilage bones there are evidences of an interclavicle and of the two clavicles. As these are considerably crushed it is difficult to be at all sure of the original condition. I can find no evidence of the interclavicle having had a posterior median process. If the interpretation of the elements here given should prove correct, then it would appear that the type of girdle in *Mesosaurus* is a modification of the type found in *Procolophon*.

It is remarkable that in the Cape Town specimen, though the impression is of the ventral surface, there are only the indications of three or four of the abdominal riblets.

It is somewhat difficult to decide with certainty the species of this specimen. It certainly differs greatly from the figure of the Paris specimen, and the question depends on what reliance can

be placed on Gervais' figure. According to Seeley we have the evidence of Gaudry that the cervical ribs in the Paris specimen are similar to those in the Cape Town specimen. If this is so, then the Paris specimen is very badly drawn indeed. In the text the humerus is stated to be 25 mm. long and 13 mm. broad, but if the figure of the humerus, which is stated to be natural size, is measured, it is found that while 25 mm. is the length, the breadth is only 9 mm. Either the measurements are incorrectly given in the text, or the drawing is so out of proportion as to be worthless. The shoulder girdle as figured is very unlike that of the Cape Town specimen, and strongly suggests that the two specimens belong to different species, but until a reliable figure is given of the Paris specimen the question must remain unsettled.

The following measurements of the Cape Town specimen may be useful for comparison with others :—

	Length.	Breadth.
Humerus	17 mm.	9·7 mm.
Radius	14·8	2·7
Ulna	14·2	2·5
1st metacarpal	4·8	2·5
2nd ,, ...	6·5	1·7
3rd ,, ...	6·8	1·5
4th ,, ...	6·4	1·5
5th ,, ...	5·2	1·2

The following are the principal measurements of the Nieuwoudtville specimen :—

	Length.	Breadth.
Femur	34·5 mm.	6·5 mm.
Tibia.....	20·5	5
1st metatarsal.....	8·7	4
2nd ,, ...	12·4	3·2
3rd ,, ...	15	about 3·2
4th ,, ...	16·5	3·3
5th ,, ...	18	2·8

Entire length of 1st digit, including metatarsal...	16 mm.
,, ,, 2nd ,, ,, ,, ...	24·6
,, ,, 3rd ,, ,, ,, ...	31
,, ,, 4th ,, ,, ,, ...	37
,, ,, 5th ,, ,, ,, ...	39·4

ADDENDUM.

(September 1, 1904.)

When writing the above paper I refrained from offering any opinion on the question of the systematic position of *Mesosaurus*, in the hope that a good skull might turn up and settle the question beyond dispute. As, however, different opinions on the question have been recently expressed by Osborn and Boulenger, and the question has an important bearing on the classification of Reptiles, it may perhaps be advisable to consider the direction in which the evidence derived from the pectoral and pelvic arches seems to point.

By Osborn *Mesosaurus* is placed in his Super-order *Diaptosauria* —a group which includes the primitive Rhynchocephalians of other writers—and the Plesiosaurs he regards as having been derived quite independently from Cotylosaurian ancestors. By Boulenger *Mesosaurus* is believed to be closely related to the early Plesiosaurians, such as *Neusticosaurus*, and the whole Plesiosaurian order to be descended from Rhynchocephalian ancestors.

While the whole question cannot be finally settled except by the skull, the evidence of the limb girdles seems to lead us a certain distance on safe ground. In *Mesosaurus* the pubis and ischium are plate-like and very similar to those bones in *Procolophon* and *Palæohatteria*. The pectoral arch also seems to be a modification of the *Procolophon* type. We may therefore conclude that *Mesosaurus* is descended from a land animal that had plate-like pubis and ischium and an ossified precoracoid. Such a land animal might be found in the *Microsauria*, *Cotylosauria*, or the *Diaptosauria*. That *Mesosaurus* is directly descended from a Microsaurian ancestor is very improbable for a number of reasons. That it is descended from a Cotylosaurian is not at all improbable, but it is much more likely that the ancestor was a primitive Rhynchocephalian or Diaptosaurian. And on this point Osborn and Boulenger seem to be agreed. But on the question of the affinities of *Mesosaurus* to the Plesiosaurs their views are very dissimilar.

The Plesiosaurs are so extremely specialised in many directions that the determination of their affinities has been a matter of great difficulty, and many very different results have been arrived at. Many writers have been impressed by the Chelonian resemblances in some of the characters, and have regarded the affinities as mainly Rhynchocephalian. The skull, however, bears much resemblance to that of the Anomodonts, and hence the Plesiosaurs have been regarded as more closely allied to the Theriodonts and Anomodonts

than to the Rhynchocephalians. This latter opinion has had the support of Smith-Woodward, Osborn, and Williston, and until recently I favoured the same view. In the Plesiosaurian skull there is, as in the Anomodonts, a single large temporal fossa, and the superficial resemblance of the two skulls is thus great. When we study the structure of the fossæ, however, we find reasons for doubting if the fossæ are really homologous. One of the peculiarities of the temporal fossa in the Anomodonts is that the inner wall is formed by the post-orbital and squamosal bones. Occasionally these bones are not fully developed and the parietal forms a part of the wall, but it is manifest that the primitive fossa has been between the post-orbital, squamosal, and jugal bones. In the Plesiosaurs the fossa is apparently a fossa between the post-orbital, parietal, and squamosal bones. It thus seems probable that the two fossæ, though apparently so similar, are really distinct in origin.

The structure of the pectoral arch in the Plesiosaurs has given rise to much dispute. There is now, however, little difference of opinion that the arch is composed of a large coracoid, a short scapula with a peculiar anterior and inner process, and a short clavicle and an interclavicle. In different genera the development of the various parts is very different, but in no known genus is there any trace of a distinct precoracoid bone. For the peculiar function of the Plesiosaurian fore limb a precoracoid would have been useful, and had it been present in the ancestor it would have been retained. The precoracoid bone is typically present in the Cotylosaurs and in the early Diaptosaurs. It is retained in the Anomodonts and Theriodonts because it is useful for the attachment of the muscles in those animals in which the body has been well supported off the ground by the fore limbs. In the lizard-like animals where the body rested mainly on the ground the need for a precoracoid disappeared, and at a very early stage in the lizard-like group the ossified precoracoid is no longer met with. Thus we find even in the very primitive *Palæohatteria* no ossified precoracoid, and it never again reappears in any of the typical reptilian groups. The need for it reappears as in the Plesiosaurs, but some other arrangement has to be effected. As the precoracoid would not have disappeared had the need for it remained, we may safely conclude that the Plesiosaurs are descended from a land animal of lizard-like habits, and which had lost its precoracoid.

If we examine the pelvic arch of the Plesiosaurs we find the evidence pointing in the same direction. The pubis and ischium of the Plesiosaurs have been described as plate-like, but they are only secondarily plate-like, while the bones in *Mesosaurus* are primarily

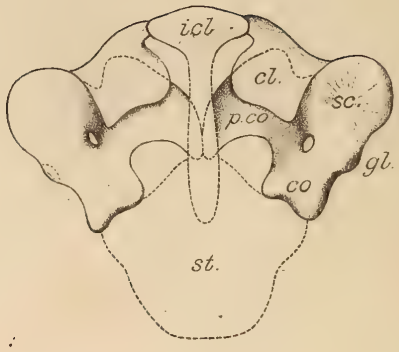
so. The pubis and ischium in the Plesiosaurs, though greatly flattened out, are probably but modifications of the radiating type seen in *Sphenodon*. Had the land ancestor of the Plesiosaurs had a plate-like pubis and ischium it would have been retained in the aquatic descendants, where there is clearly a need for the plate-like form, but as the pubis and ischium are only secondarily flattened it is evident that the land ancestor of the Plesiosaurs had a pelvis somewhat resembling the Sphenodon type.

The Plesiosaurian skull is not likely to have been derived from a type like that of *Sphenodon*, though the temporal vacuity is probably homologous with the upper vacuity of the *Sphenodon* skull. It seems more probable that the Plesiosaurs are sprung from a land ancestor somewhat resembling *Sphenodon* in general characters, but with only a single supra-temporal fossa. In Permian times there must have been a very large number of land types of which we know little except their specialised Triassic descendants. The Phytosaurians, the Ichthyosaurs, the Plesiosaurs, the Proterosaurs, the Pelycosaurs, and the Proganosaurs, all point to there having been a large group of land reptiles resembling in many ways the Rhynchocephalians, but much more primitive in many characters. For this large group Osborn's name of *Diaptosauria* seems the most suitable. The more primitive members of it had the skull roofed as in the Cotylosaurs, and retained the precoracoid and the plate-like pubis and ischium. *Procolophon* is evidently a descendant of these earlier types, and so probably is *Mesosaurus*. The higher members of the group, owing to their lizard-like habits, lost the precoracoid, and had the pelvis modified into a tri-radiating type. First an upper, then a lower temporal fossa seems to have been formed, though possibly in some types the order may have been reversed. From some of these higher types with only the supra-temporal fossa in all probability sprang the Plesiosaurs.

It would thus seem probable that *Mesosaurus* and the Plesiosaurs are descended from different and rather dissimilar land animals, which, as being members of the same large Super-order, the *Diaptosauria*, had, however, a good many characters in common—especially the Diapsidan digital formula and well-developed abdominal ribs. A few other characters which the groups have in common appear to be due to similar specialisations to suit like habits.

Boulenger in his forthcoming paper on *Telerpeton*, of which he has kindly sent me a proof, objects to Osborn's names for the subdivisions of the Reptilia—*Diapsida* and *Synapsida*—owing mainly to Osborn's inclusion in the latter of the Plesiosaurs and Chelonians. While I am inclined to think that Boulenger is right in removing

the Plesiosaurs and Chelonians from association with the Anomodonts, I think it will nevertheless be advisable to retain Osborn's names. Boulenger prefers Cope's name of *Theromora* for the mammal-like reptiles; but this name seems untenable owing to Cope's having made the Pelycosaurs the type of the group—forms which Boulenger agrees in placing in the Rhynchocephalian division. Boulenger's group—the *Herpetomorpha*—is nearly synonymous with Osborn's *Diapsida*.



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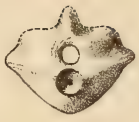

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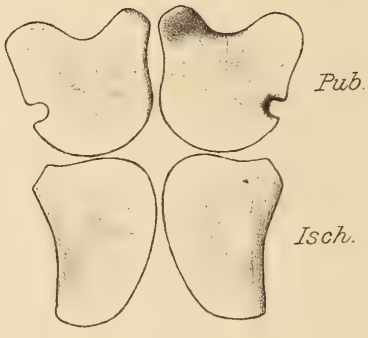

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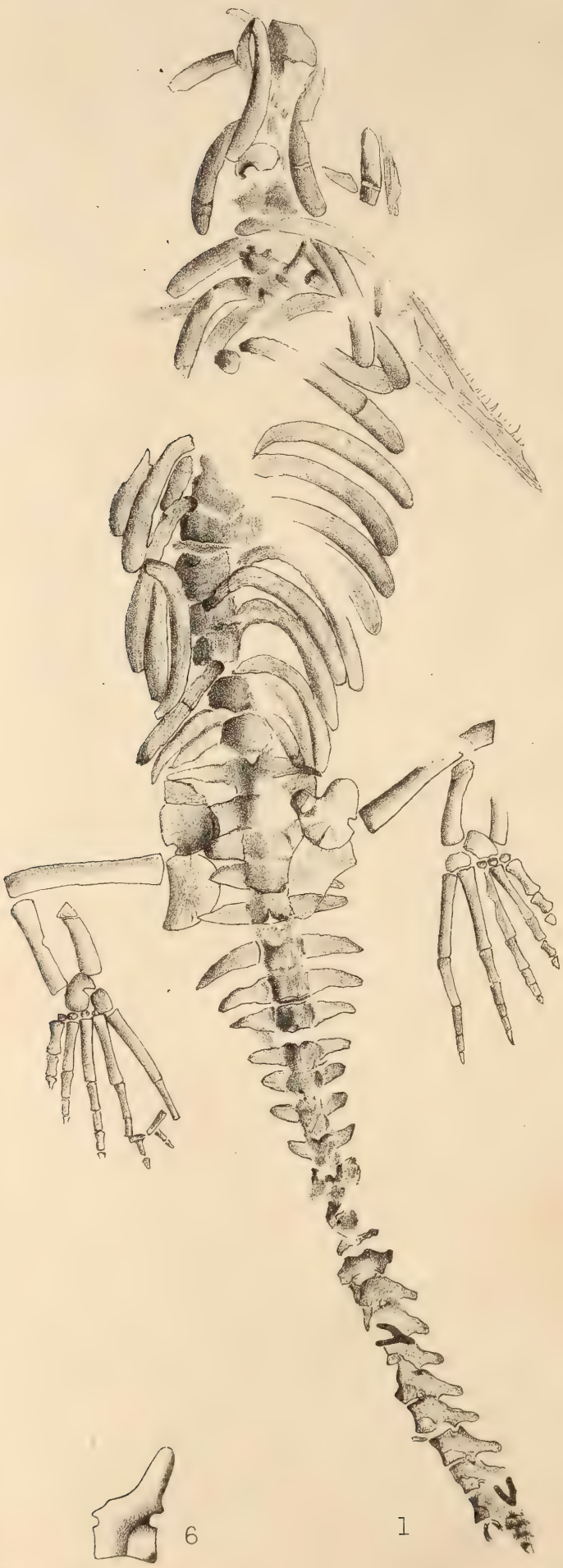

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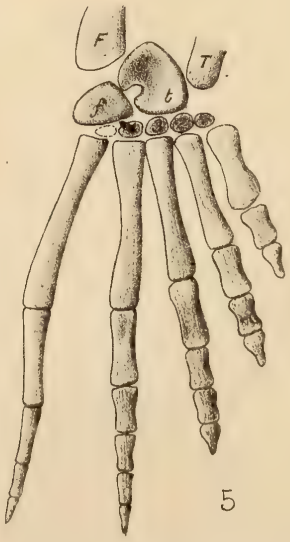

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R. Broom del.

West, Newman lith. London.

STRUCTURE OF MESOSAURUS.

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REFERENCES TO PLATE.

References to lettering:—*cl.* clavicle; *co.* coracoid; F. fibula; *f.* fibulare; *gl.* glenoid cavity; *i.* intermedium; *i.cl.* interclavicle; *isch.* ischium; *p.co.* precoracoid; *Pub.* pubis; *sc.* scapula; *st.* sternum; T. tibia; *t.* tibiale; 1. 2. 3. 4. the four tarsalia.

Fig.

1. Representation of the Nieuwoudtville specimen of *Mesosaurus*. × ·58.
2. Attempted restoration of the shoulder girdle of *Mesosaurus*. Nat. size.
3. Anterior view of a dorsal vertebra showing the ridges to which are attached the ribs. Nat. size.
4. Restoration of the ventral elements of the pelvis. Nat. size.
5. Restoration of the pes of *Mesosaurus*. Nat. size.
6. The 17th caudal vertebra, showing the line of splitting. Nat. size.

DESCRIPTIONS OF NEW GENERA AND SPECIES OF SOUTH AFRICAN SPIDERS.

By W. F. Purcell, Ph.D.,

First Assistant in the South African Museum, Cape Town.

(Read June 29, 1904.)

Plates X., XI.

The present paper contains descriptions of 4 new genera and 62 new species of South African Spiders contained in the Collection of the South African Museum.

With the exception of 3 new species of *Prodidomidæ*, all of them belong to the groups *Mygalomorphæ* (*Migidæ*, 1 n. sp.; *Ctenizidæ*, 1 n. gen. and 5 n. spp.; *Barychelidæ*, 2 n. spp.), *Cribellatæ* (*Uloboridæ*, 1 n. gen. and 3 n. spp.; *Dictynidæ*, 4 n. spp.; *Eresidæ*, 6 n. spp.), and *Ecribellatæ Haplogynæ* (*Sicariidæ*, 19 n. spp.; *Dysderidæ*, 1 n. gen. and 11 n. spp.; *Caponiidæ*, 1 n. gen. and 8 n. spp.).

Family MIGIDÆ.

Moggridgea nigra, n. sp.

2 ♀ ♀ (Nos.* 12761–2) with their nests, found in a wall at Ashton, Robertson Div., Cape Colony, by Mr. T. O'Connor in May, 1903. Very closely allied to *M. coegensis*, Purc. (Ann. S. Afr. Mus., vol. iii., p. 71).

Colour much darker, dark brown to nearly black, the 2 posterior pairs of legs and the patellæ of the 2 anterior pairs a little lighter; under surface (also of abdomen) pale ochraceous or greenish ochraceous, the coxæ of the pedipalps and the labium reddish-yellow.

Carapace longer and less rotundate, its width not more than $1\frac{3}{4}$ times that of the ocular area (the width of the carapace in *M. coegensis*

* Numbers in Museum Catalogue.

being almost twice that of the ocular area), its length equal to or less than that of the fourth tibia and metatarsus.

Total length (including chelicera) 19 mm.; length of carapace 8, width $6\frac{4}{5}$.

Nests.—The nest consists of a longish oval sack, which was evidently embedded in the mud wall. The opening is placed at one end of the longer surface, so that the door when closed lies parallel to the long axis of the sack. The door itself is **D**-shaped, thick and rigid, but thinner at the edge, like that of *M. mordax*, Purc. (Ann. S. Afr. Mus., vol. iii., p. 70, fig. 1), but with a narrower hinge. The upper surface of the door is covered with mud and small pebbles, while the lower surface is lined with white web and is slightly concave, becoming convex only towards the margin. The centre of the under surface is either without pits or is provided with several pairs. Length of a nest 50 mm., width at 10 mm. from opening 16. Width of door taken parallel to hinge $21\frac{1}{2}$, at right angles to hinge $16\frac{1}{2}$; width of hinge $16\frac{1}{2}$, thickness of door in middle $2\frac{1}{4}$; width of carapace of occupant $6\frac{4}{5}$.

Family CTENIZIDÆ.

Gen. IDIOPS, Perty.

Idiops pungwensis, n. sp.

1 ♂ (No. 13576) from the north side of the Pungwe River in Portuguese East Africa, about 50 miles east of Umtali, at an altitude of about 2,100 feet (*D. L. Patrick*). Very like *Ctenolophus cregoei* (Purc., Trans. S. A. Phil. Soc., vol. xi., p. 352, 1902), but differing principally in the following respects :—

Colour pale ochraceous, in parts, especially the posterior part of the cephalic area and the anterior pair of legs, rufescent, the tibiæ of these legs deep red on the inner side at apex; granular areas on cephalic portion of carapace infuscate; under side pale yellowish; abdomen purplish-black above.

Carapace granular, with a pair of spines posterior to the ocular area; its length equal to that of the metatarsus and $\frac{2}{3}$ of the tarsus of first leg. Ocular area short, its length only slightly exceeding $\frac{1}{3}$ of the distance from its anterior margin to the middle of the fovea. Area formed by the four anterior eyes decidedly wider behind than in front, its length scarcely $1\frac{1}{2}$ times its posterior width; frontal eyes very prominent, somewhat conically pointed above, close together but separated by a deep cleft. Posterior median eyes 3–4

times as far from one another as from the lateral eyes, the latter regularly oval and not attenuated behind, scarcely reniform; area formed by the 4 median eyes much wider than long and only very slightly wider behind than in front.

Pedipalps.—Tibia moderately turgid, its length more than twice its height (which is equal to the length of the tarsus) and less than twice the length of the patella, the short spines and spinules bordering the notch irregularly uniseriate in the distal half of the band but about 4-seriate in the broad proximal half, which ends behind the middle of the under surface. Tarsus with an apical group of spines, its outer distal angle produced into a narrow lobe; process of bulb large, very thick, the distal portion curving forwards and concave in front, the apex broad, rounded externally but angular internally, and provided behind with a short curved spine.

Legs.—Tarsi I.–II. with 0 inner and 3–4 outer spines, III. with 2 anterior and 3 posterior spines, IV. with 1 inner and 4–5 outer spines. *Metatarsus* I. slightly curved and slightly thickened near the middle, its inner side not concave and only slightly thickened near the middle where it is unarmed or provided with a short spine, the apex with 2 spines; outer side with 6 inferior spines, extending to near base. *Tibia* I. a little shorter than the metatarsus.

Sternal sagilla small, submarginal, the posterior pair a diameter and a half from the edge.

Chelicera with two well-developed rows of teeth below, each composed of 3–4 large teeth alternating with two small teeth, the rows of equal length.

Total length (including chelicera) 12 mm., length of carapace $4\frac{3}{4}$, length of first tibia $3\frac{1}{3}$.

Gen. CTENOLOPHUS, n. gen.

Allied to *Idiops*. Chelicera with a single row of large teeth below, the teeth of the outer row being reduced to a few small posterior denticles remote from the anterior end of lower margin; the apical process rather large and well developed. Posterior row of eyes procurved, the lateral eyes emarginate internally, the area formed by the 4 median eyes wider behind than in front in the ♀. Labium slightly (type) or more considerably broader than long, with 2–4 apical teeth in a single row. Sternum with 2 pairs of small marginal sagilla. Coxæ of third pair of legs without (type) or with a strip of stout setæ along hind margin of under side; anterior coxæ without spinules on the sides.

Type : C. kolbei (Purc.) (Trans. S. A. Phil. Soc., vol. xi., p. 353, 1902, *sub Acanthodon*).

The following species also belong to this genus :—

C. kentanicus (♀), *C. spiricola* (♀), *C. cregoei* (♂) and *C. pectinipalpis* (♂), (Purc.), all described under *Acanthodon*. In the two latter (males) the area formed by the 4 median eyes is parallel-sided.

The following is a synopsis of the South African *Idiopinæ** known to me :—

a. Under side of chelicera with both outer and inner row of teeth well developed and reaching to distal margin.

a^1. Tibia of third leg impressed above at base (Gen. *Heligmomerus*). Selati Distr., Transvaal .. .. ♀ *H. caffer*,† Purc.

b^1. Tibia of third leg not impressed above at base (Gen. *Idiops*).

a^2. ♀ ♀.

a^3. Anterior surface of coxæ of first two pairs of legs thickly covered with short, sharp spinules. Area formed by the 4 median eyes broader behind than in front. Umtali, Mashonaland. *I. versicolor* (Purc.).

b^3. Coxæ of legs without spinules. Area formed by the 4 median eyes parallel-sided. Johannesburg .. .. *I. fryi* (Purc.).

b^2. ♂. Portuguese East Africa (Pungwe River) .. *I. pungwensis*, n. sp.

b. Under side of chelicera with an inner row of 4–6 strong teeth, which extends from distal margin to middle, and is flanked on outer side at posterior end by a very short single or double series of teeth.

a^4. Sternum with 2 pairs of sagilla, the anterior pair marginal, the posterior pair marginal or submarginal, at most about their own length from the lateral margin. Under side of chelicera with 2–9 small or minute outer flanking teeth in middle.

a^5. Abdomen soft-skinned (Gen. *Ctenolophus*, n.g.).

a^6. ♀ ♀.

a^7. Coxa of third leg with a strip of stout spiniform setæ along posterior margin of lower surface. Frontal eyes large and very close together ; ocular area long, almost $\frac{1}{3}$ of the length of the carapace. Kentani Distr. .. .. *C. kentanicus* (Purc.).

b^7. Coxa of third leg with slender setæ. Frontal eyes further apart, placed on quite separate tubercles ; ocular area short, less than $\frac{1}{4}$ of the length of the carapace.

a^8. Abdomen with setigerous tubercles above. Size larger. Kentani Distr. .. .. *C. kolbei* (Purc.).

b^8. Abdomen without tubercles above. Size smaller. Kentani Distr... .. .. *C. spiricola* (Purc.).

b^6. ♂ ♂.

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* The generic position of the following South African species is not known to me : *Acanthodon flaveolum*, *hamiltoni*, *ochreolum*, and *pretoriæ*, Poc., *Idiops thorelli*, O. P. Cambr.

† *H. deserti*, Pocock (Ann. Mag. N. H. (7), vol. vii., p. 286, 1901), from the Kalahari Desert is not known to me.

a^9. Distal portion of process of palpal organ flattened and broad, strongly bent. Durban .. .. *C. cregoei* (Purc.).

b^9. Distal portion of process of palpal organ slender and subterete, slightly curved. Zululand .. .. .. *C. pectinipalpis* (Purc.).

b^5. Abdomen hard-skinned above (Gen. *Galeosoma*). Johannesburg.
♀ *G. scutatum*, Purc.

b^4. Sternum with 3 pairs of sagilla, all of them remote from the margin. Under side of chelicera with 2 (sometimes 1) powerful outer flanking teeth in middle, sometimes accompanied by a smaller posterior third tooth (Gen. *Gorgyrella*).

a^{10}. Coxa of first leg with large denticulate area, which is almost as extensive as that on coxa of second leg. Van Rhyns Dorp and Namaqualand Divs... .. .. ♀ *G. namaquensis*, Purc.

b^{10}. Coxa of first leg without denticulate area, or this area very much less extensive than that on coxa of second leg. Hanover Div.
♀ *G. schreineri*, Purc.

Gen. ANCYLOTRYPA, E. Sim.

Ancylotrypa cornuta, n. sp.

1 ♂ (No. 12801) from Dunbrody, Uitenhage Div., Cape Colony (*Rev. J. A. O'Neil*).

Colour.—Carapace and chelicera reddish-brown; sternum and legs yellowish-brown, the latter paler distally; abdomen blackened above and at the sides, pallid below, the lung-opercula and the spinners pale yellowish.

Carapace as long as the metatarsus and tarsus of first leg, and as the metatarsus and ⅔ of the tarsus of fourth leg, provided with a few black spines and fine setæ behind. *Ocular area* over 2½ times as wide as long and a trifle wider behind than in front; both margins of anterior row of eyes (seen from above) a trifle procurved, the median eyes rather small, much smaller than the laterals, and scarcely, if at all, longer than the posterior laterals; posterior row of eyes as in *A. pusilla*, Purc. (Ann. S. Afr. Mus., vol. iii., p. 27, 1903), except that the median eyes are oval.

Pedipalps.—Femur produced at apex above into a *short obtuse horn*, behind which are a pair of low tubercles; palpal organ much as in *A. pusilla*, except that the spine is longer, with the thick basal portion also slightly (spirally) curved.

Legs.—*Tarsi* scopulate, I. with a double (irregular) row of about 14 small, stout spines below, beside a distal spine on the outer surface; II. with about 7 inferior but no outer spines; III. with 1–2 dorsal and about 7 outer and 3 inner spines, besides 1–2 in the scopula; IV. with about 4 spines along inner lower edge, 8 (several paired) along outer lower edge, and 5 smaller ones in the scopula. *Metatarsi* with small distal patch of scopular hairs, the anterior

pairs slightly curved; I. with 13–16 rather short spines below, roughly arranged in 2 rows, the inner surface with a strong mesial spine besides; II. with 6 outer and 3 inner spines below, besides a mesial one on the inner surface. *Tibia* I. very slightly curved, scarcely longer than the metatarsus, with 5 rows of spines, viz., an outer row of 3, an outer inferior row of 6, an inner inferior row of 4–5, and an inner row of 3, besides an odd apical and sometimes a basal spine situated between the two latter rows.

Posterior spinners with the apical segment acuminate, slightly longer than the middle one.

Abdomen with numerous short spines above.

Sternal sagilla slightly nearer to the margin than in *A. pusilla*.

Total length 9½ mm.; length of carapace 4.

Gen. PELMATORYCTER, Poc.

Pelmatorycter pallidipes, n. sp.

1 ♂ (No. 12780) from Matjesfontein, Cape Colony, October, 1903 (*W. F. P.*).

Colour.—Carapace pale ochraceous and lightly infuscated in places on the thoracic portion, the cephalic portion brown; chelicera darker brown; legs, sternum, coxæ, and abdomen pale yellowish, the 4 distal segments of first leg reddish, the sternum slightly infuscated at anterior and lateral margins, the abdomen blackened on the dorsal surface and round the group of spinners; hairs black.

Carapace as long as the tibia and ½ the metatarsus, but slightly exceeding the metatarsus and tarsus of first leg, and a little shorter than the metatarsus and tarsus of fourth leg; posterior marginal spines subsetiform, present above the coxæ of fourth pair of legs only, the posterior surface with a few sigmoid spines.

Ocular area a little wider behind than in front; the anterior row slightly procurved, the eyes equi-distant, the laterals large, about ⅓ longer than the medians; the posterior row strongly recurved, the lateral eyes long, oval, distant about their own length or slightly less from the anterior laterals and a little longer than the anterior medians; posterior median eyes slightly oval, about two-thirds as long as the laterals.

Pedipalps as in *P. nigriceps* (Purc.) (Trans. S. Afr. Phil. Soc., vol. xi., p. 358, 1902), except that the spine of the palpal organ is a little longer than the bulb.

Legs.—*Tarsus* I. rather thinly scopulate, lightly concave on under side and not inflated, without spines; II.–IV. slightly inflated below,

being convex along under side and more densely scopulate, II. also unspined, III. with 1 dorsal spine, IV. with 0–1 spine on inner surface at apex and 2 on outer surface. *Metatarsi* I. and II. not scopulate, I. slightly concave along both inner and under sides, under surface with 0–1 inner (basal) and 3 outer spines, outer surface with 1 inferior apical spine, and inner surface with 1–2 (mesial and basal) spines; III. and IV. with small apical patch of scopular hairs. *Tibia* I. as long as the metatarsus, the under side with a double row composed of 5 outer and 4 inner spines, the outer side besides with 1 and the inner side with 5 other spines.

Abdomen with some long setiform spines at base above. *Posterior spinners* with the apical segment subequal to or slightly longer than the middle segment, these 2 segments together longer than the basal segment.

Sternal sagilla as in *P. nigriceps* (Purc.).

Total length (including chelicera) 12½ mm.; length of carapace 5¼.

Gen. SPIROCTENUS, E. Sim.*

1. Spiroctenus pallidipes, n. sp.

Specimens.—6 ♂ ♂ and 18 ♀ ♀, all adults, collected at Touws River Station, Worcester Div., by my wife, Mr. R. M. Lightfoot, and myself in August, 1903.

Closely allied to *S. lightfooti*, (Purc.) (Trans. S. A. Phil. Soc., vol. xi., p. 363), which it resembles in most respects.

Colour pale yellowish, the chelicera reddish ochraceous, the carapace often faintly infuscated, the dorsal surface of the abdomen with a well-defined pattern composed of a series of arcuate, transverse, black or purplish-black stripes united by a median longitudinal stripe, the anterior stripe not expanded into a large patch; sides of abdomen and under surface without marks, excepting a black spot above and sometimes a smaller one in front of each of the posterior spinners; legs very pale yellowish, concolorous, the femora not darker than the distal segments.

♀ ♀. *Carapace* as long as or slightly longer than the tibia and ½ the metatarsus of fourth leg, but a little shorter than or subequal to the tibia and metatarsus of first leg; fovea a deep transverse

* According to Simon *Spiroctenus*, E. Sim. = *Hermachastes*, Poc., and I may add that *Bemmeris pardalina*, E. Sim. (Bull. Soc. Ent. Fr., 1902, p. 42), is evidently an immature example of *Hermachastes collinus*, Poc., while *Ctenonemus pectiniger*, E. Sim. (*ibid.*, p. 43), is also a young *Hermachastes*. Both these genera, therefore, must be added to the synonyms of *Spiroctenus*.

(rarely slightly recurved) cavity. Anterior lateral eyes oval, not large, and about as long as the strongly convex anterior median eyes.

Chelicera longish, with the spines and spiniform setæ of the rastellum in a single row, numerous but not very densely crowded together; the under surface (measured along the groove) longer than the median length of the sternum; the outer row of teeth very feeble, composed of 5–9 minute granules, occupying not more than the middle third of the inferior groove, and less (generally much less) than half as long as the inner row.

Posterior spinners with the apical segment as long as the penultimate one or only slightly shorter.

Labium with 0–4 apical teeth. *Coxæ of pedipalps* with few (2–14) teeth at base.

Legs without scopulæ. *Metatarsi* I. and II. with 2 (rarely 1) inner and 3–4 (rarely only 2) outer spines below (the outer apical spine being generally duplicated); II. with 1–2 superior inner spines as well; IV. and generally also III. with an infero-posterior apical tuft of 2–4 small spiniform setæ placed between 2 stout spines. *Tibiæ* I. and II. with 0–1 inner and 3 outer spines below (the proximal ones slender and often setiform at apex), and 1–2 slender spines in upper part of inner surface. *Claws* of anterior legs with 5–6 (rarely 4) teeth in the basal row, and 5–7 small teeth in the row nearest the axis of the leg, these rows overlapping for a small portion of their length; claws of fourth leg with 4–6 teeth in the basal row and 3–5 in the distal row.

♂ ♂. *Carapace* a little longer than the first but considerably shorter than the fourth metatarsus. Fovea slightly recurved.

Chelicera with the inferior groove subequal to or longer than the median length of the sternum, the inferior teeth as in the ♀.

Labium muticous. *Coxæ of pedipalps* with 0–6 teeth at base.

Pedipalps.—Spine of palpal organ longer than the bulb, conical and thick in basal half but slender and filiform in the distal part.

Legs.—*Tarsi* muticous, lightly curving upwards distally, the under surface with rather thin scopula, which is distinctly divided in I.–III. by a row, and in IV. by a narrow band of black bristles. *Metatarsi* I. and II. straight or lightly incurved, their under side sparsely scopulate distally and provided with 2 inner and 4–5 outer spines, the outer surface besides with 2–3 upper spines, and the inner surface with 1 distal and 1 nearly straight mesial spine; III. also sparsely scopulate distally; IV. with very few or scarcely any scopular hairs. *Tibia* I. only slightly or hardly at all incrassated distally, spurred as in *lightfooti*, but more numerously and stoutly

spined, the under surface having 1–2 inner, 3 outer, and often 1–2 mesial spines, the outer and inner surfaces each with 2–4 other spines in addition; the inner apical spine on under surface stout but much slenderer than the adjacent spur and situated close to it on its inner side, the spur and spine being separated at base by not more than the width of the spur.

Length of trunk (carapace + abdomen), ♂ ♂ 11⅓–14 mm., largest ♀ 20; length of carapace, ♂ ♂ 5–5½, ♀ 7.

Nests.—The nests, of which I dug up a large number in the loose

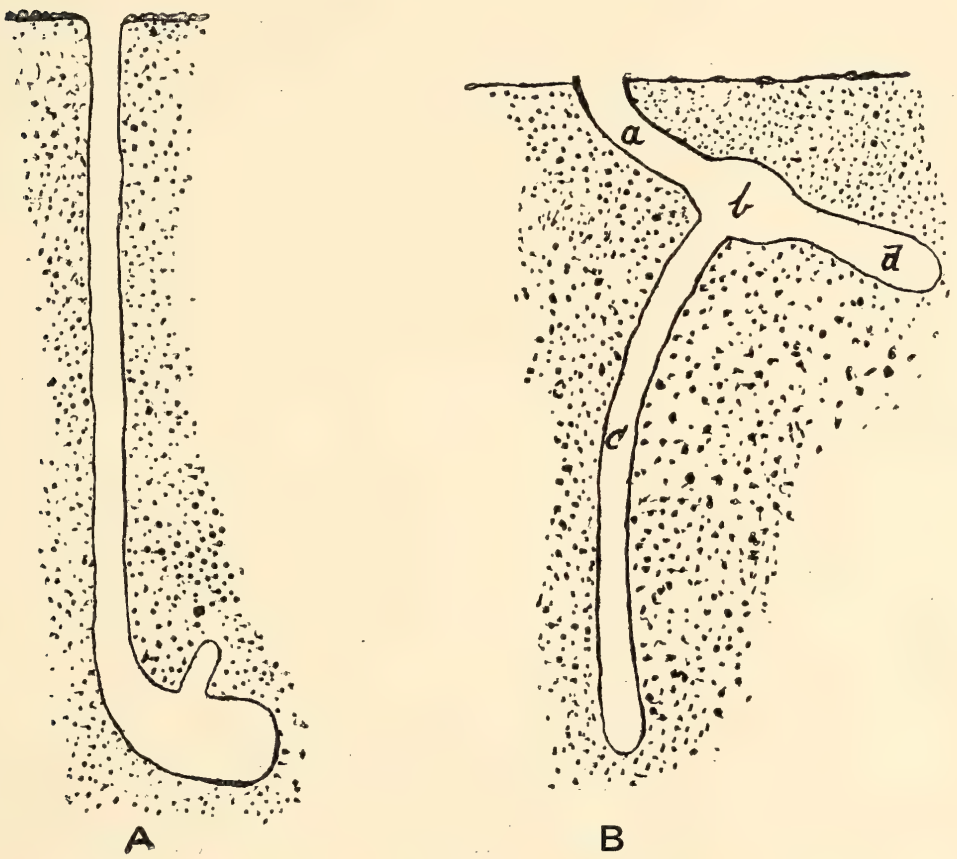


Fig. A. Burrow of *Spiroctenus pallidipes*, n. sp., in vertical section (⅓ nat. size).
Fig. B. Burrow of *S. pectiniger* (E. Sim.) in vertical section (⅓ nat. size).

red sand near the river, were all built on the same plan, and consisted of a vertical burrow, sometimes inclined for 2–3 cm. at the entrance, where it is about 8–11 mm. in diameter, while at a depth of about 18–23 cm. the burrow curves sideways and enlarges into a chamber 2½ cm. or more in diameter and generally about 5 cm. in length. At 2½–7½ cm. from the end of the chamber in its upper wall is a small side chamber just large enough to contain the spider, and here she almost always hides when her burrow is du up. This side-chamber is sometimes nearly vertical and sometimes nearly

horizontal. In the large chamber remains of beetles were generally found. The burrows were generally very deep, frequently 35 cm. in depth, but sometimes (in hard clay) only 18 cm. Most of the burrows were without any silken lining (owing, perhaps, to the moist nature of the soil at the time, which prevented the sand from falling in), but in some cases the upper part was lined with web. No attempt at a turret round the entrance was met with.

The ♂ ♂ were mostly found under stones and old tins, but one was discovered in a burrow 7½ cm. deep.

S. pectiniger (*Ctenonemus pectiniger*, E. Sim.), of which we obtained 3 ♂ ♂, 14 ♀ ♀, and 3 juv. at Matjesfontein, is very closely allied to *pallidipes*, n. sp., from which the ♀ differs as follows: Colour slightly darker, the legs tinged with greenish; abdomen with large patch of blackish-purple in front, the posterior stripes also often continued down the sides. Chelicera shorter, the length of the inferior groove subequalling but not exceeding the median length of the sternum, the outer row of teeth below longer and much stronger, its length being ½ (rarely only ⅔) of that of the groove and exceeding (rarely subequalling) half that of the inner row, the teeth 10–16 in number, the posterior part of the row being frequently doubled and the anterior ones much stronger than in *pallidipes*. The ♂ differs further in having the scopulæ in tarsi I.–III. denser and broader and practically entire, the setæ of the dividing line being very minute or obsolete, the fourth tarsus quite without scopula, and the inner apical spine on under side of first tibia placed more proximally to the distal spur, the spur and spine being separated at base by nearly or quite twice the width of the spur.

I also examined a large number of the nests of *pectiniger*, which were common everywhere from the river to the tops of the hills. Fig. B, which was sketched from an actual nest, represents the general plan upon which these nests are constructed, and shows (*a*) a short, inclined, silk-lined tube, 11 mm. in diameter at the entrance and 4½ cm. in length, leading into (*b*) an enlarged chamber, 23 mm. in diameter, out of which two other tubes lead, namely, (*c*) a deep and more or less vertical burrow, 9½ mm. in diameter and descending to a depth of about 20½ cm. from the surface, and (*d*) a short and more horizontal burrow 42 mm. in length. At the entrance the burrow is, as a rule, not more than 13 mm. in diameter (rarely as much as 16 mm.), and the silken lining spreads out slightly and is either flush with the surface of the ground or more generally projects slightly to form a very short turret, which does not, however, exceed 3½ mm. in height, and is covered with bits of wood and stone adhering to its outer surface. The short blind chamber (*d*) is very variable in position,

being sometimes directly opposite the entrance tube and in a line with it, but often to the right or left of it; it may also descend or ascend slightly or be horizontal. It seems to be used as a dining-room, for it almost always contained remains of insects, sometimes in considerable quantities. The deepest tube is always narrower than the entrance tube, and descends to a depth of about 20½ cm., and sometimes even as much as 25½ cm. The spider was always found at the bottom of this, the deepest burrow.

2. Spiroctenus latus, n. sp.

1 ♂ (No. 12804) from Wellington (*G. French*, October, 1903).

Colour.—Carapace reddish-yellow, the head and the median part behind infuscated, the margins blackened; chelicera dark brown, reddish-yellow at base; legs infuscated, also below, paler at distal extremity, especially below, the patellæ pale yellowish to reddish-yellow on the naked strips above; coxæ and sternum pale ochraceous; abdomen pale yellow, the dorsal and upper part of lateral surfaces with thick black reticulation, ventral surface with a transverse row of black marks before the spinners, the lung-opercula brownish laterally.

Carapace as long as the metatarsus and ¾ of the tarsus of the fourth leg, but subequal to the tibia and metatarsus and longer than the metatarsus and tarsus of first leg. Eyes disposed much as in *S. collinus* (Poc.), the anterior laterals much larger than the anterior medians and posterior laterals, the posterior medians very small, much smaller than the other eyes.

Chelicera with the inferior groove much shorter than the median length of the sternum, the outer row of teeth in the groove extending forwards a little beyond the middle of the inner row and composed of numerous minute teeth, the row duplicated behind.

Labium with 2 apical teeth. *Coxæ of pedipalps* with about 25 basal teeth.

Sternum with the sagilla of the posterior pair narrow, elongate.

Posterior spinners short, the apical segment almost hemispherical and about half as long as the penultimate segment.

Pedipalps.—Tibia with an internal spine near apex; spine of palpal organ shorter than the bulb, conical at the base but finely subulate distally.

Legs short. *Tarsi* muticous, those of the third pair slightly curving upwards at base, the others quite straight, I.–III. scopulate below, the bristles along the middle of the scopula very minute, almost obsolete in I. and II., distinct but very slender in III.; IV.

without scopula. *Metatarsus* I. strongly curved, being concave below in the basal two-thirds, the under side scopulate distally and provided with 1 inner and 3 outer spines, the outer surface besides with 1 spine and the inner surface with a pair of strong mesial spines; II. only slightly curved, scopulate distally, with 1–3 inner and 2–3 outer spines below, the outer surface besides with 0–1 spine and the inner surface with 2–4 other spines; III. and IV. not scopulate distally. *Tibia* I. stout, only slightly incrassated distally, the 2 spurs resembling those of *S. collinus*, the under surface with 1–2 inner and 3 outer spines, the outer surface with no other spines but the inner surface with 3; the inner apical spine on under surface situated as in *pallidipes*, n. sp.

Length of trunk $10\frac{1}{3}$ mm., of carapace 5; width of carapace $4\frac{1}{4}$.

A very distinct species, related to *S. collinus* (Poc.), *tricalcaratus* and *gooldi* (Purc.), but with much slenderer palpal spine and darker and shorter legs. In the shortness of its legs it resembles *S. lightfooti* (Purc.).

Family BARYCHELIDÆ.

Harpactirella schwarzi, n. sp.

1 ♀ (No. 12928) from Vleikuil, north of Blyde Berg, Willowmore Div., Cape Colony (*E. H. L. Schwarz*).

Closely allied to *H. karrooica*, Purc. (Trans. S. A. Phil. Soc., vol. xi., p. 344, 1902), but slightly darker in colour.

Carapace (measured laterally to the ocular area) slightly longer than the tibia and metatarsus of first leg. Posterior median eyes small, shortly oval or subrotund, much shorter than the anterior median eyes, and separated from the latter by their own width. (In *karrooica* these eyes are larger, more strongly truncated behind, and separated by less than half their own width from the anterior median eyes.)

Tibia of first leg slightly exceeding the metatarsus in length, but much shorter than the distance from the fovea to the posterior margin of the ocular tubercle. Anterior *metatarsi* not spined.

Apical segment of *spinners* distinctly (about $\frac{1}{5}$) longer than the middle segment but a little shorter than the ocular tubercle.

Length (including chelicera) 27 mm., length of carapace $10\frac{1}{4}$.

Brachionopus pretoriæ, n. sp.

1 ex. (No. 12769) from Pretoria (*J. Williamson*).

Colour brownish-yellow, the legs pale yellowish in parts, especially

below; the abdomen blackened above, with yellow dots, its under surface pale yellowish; carapace with its lateral and posterior edges finely blackened.

Carapace as long as the patella, tibia, and $\frac{2}{5}$ of the metatarsus of first leg, but shorter than the fourth tibia and metatarsus. Ocular tubercle distant only about $\frac{1}{4}$ of its length from the anterior edge of the carapace.

Legs.—Tarsi I. and II. with the scopula entire; III. with a row of fine setæ at most imperfectly dividing the scopula; IV. with the scopula distinctly divided by a row of long setæ. *Metatarsi* I. and II. without apical spine, the scopulæ quite entire, more extensive than in *annulatus* or *tristis*, Purc. (Ann. S. Afr. Mus., vol. iii., p. 105), the length covered by it being only a little less than that covered by the scopula of the tarsus; III. with a row of bristles imperfectly or hardly dividing the scopula; IV. with the scopula divided by a row of stout setæ. *Tibiæ* I. and II. unspined, III. and IV. with longish spines on both outer and inner surfaces, besides several at the apex below.

Labium with about 21 teeth in several rows. *Coxæ of pedipalps* with dense basal patch of about 90 teeth.

Spinners very short, the apical segment hemispherical, only about $\frac{1}{2}$ as long as the middle segment, these 2 segments together about equalling the basal segment in length.

Total length about 16 mm.

This species approaches *Harpactirella* more closely than do any of those previously described.

Family ULOBORIDÆ.

Gen. MENNEUS, E. Sim.

Menneus dromedarius, n. sp.

1 ♀ (No. 11536) from the Pirie Bush, King Williamstown (*F. A. Pym*, March, 1902).

Carapace yellowish down the middle, blackened laterally and with several triangular yellow marks at the lateral margins; the surface clothed with minute black and brown spinules and patches of fine white hairs. Length of carapace $\frac{1}{2}$ that of the first metatarsus. Eyes agreeing with Pocock's description of those of *M. camelus* (Ann. Mag. Nat. Hist., ser. 7, vol. x., p. 326), except that the posterior medians appear larger and slightly less than 3 diameters apart; anterior row of eyes much wider than the posterior row.

Abdomen yellowish, variegated with black, the hairs and spines like those on the carapace; the under surface whitish laterally and with large dark area along middle; the dorsal process thick, cylindrical, abruptly truncated at apex, asymmetrically coloured, its length only about $\frac{2}{3}$ that of the carapace. Portion of vulva which is externally visible forming a broad transverse plate with parallel, blackened lateral edges, straight posterior margin and somewhat rounded anterior margin; within the epigastric fold the plate is broadly dilated towards each side behind.

Sternum blackened laterally. *Labium* black, the tip and the lateral margins narrowly blackened. Free portion of *maxillæ* blackened laterally but white internally below.

Chelicera with a lateral and 2 anterior black stripes and with 4 teeth in the anterior and 5 in the posterior row, the fourth tooth from the distal end being the smallest in each row.

Legs yellow, variegated with black, with black spines and numerous hairs, the under side of the femora of the second and third pairs with a longer mane of reddish, white-tipped hairs.

Total length (not including chelicera) $11\frac{1}{2}$ mm.; length of carapace 4·9; length of abdomen $6\frac{1}{2}$, length to apex of tubercle $7\frac{3}{4}$, width 3·6; length of first leg (from apex of coxa) 33, of fourth leg $16\frac{1}{2}$.

Gen. AVELLOPSIS, n. gen.

Resembling the Australian form *Avella* as described and figured by O. P. Cambridge (P. Z. S., 1877, p. 574, pl. lvii., fig. 10), and differing from *Menneus*, E. Sim., in having the thorax dilated on each side at the middle, the sternum broader and the abdomen bituberculate near the middle above, but differing from *Avella* in having the tarsi in both sexes cylindrical and quite unsegmented. The head also is higher than in these two genera.

Avellopsis capensis, n. sp.

Specimens.—4 ♀ ♀, 2 ♂ ♂, and a number of young (Nos. 748, 9187, 12330) from the Cape Peninsula (St. James, Camps Bay, Bergvliet Flats, Kalk Bay Mountain) (♀ ♀ in March and April, ♂ ♂ in March).

♀ ♀. *Carapace* slightly longer than half the metatarsus of first leg, strongly dilated on each side just before the middle, being strongly constricted in front of the dilation and much narrowed posteriorly; the cephalic region distinctly elevated and marked off on each side by an oblique depression, its anterior surface rather high, vertical, at least as long as half the length of the chelicera, its

upper surface depressed between the 2 posterior eyes but convex behind the depression. Integument olive-greenish or olive-brown, with a median white stripe running along the thorax and spreading over the posterior part of the head up to each posterior lateral eye; anterior surface of head more blackened and bordered behind and laterally by a transverse arcuate white line running from each anterior lateral angle upwards between the pair of median eyes on each side to the median line. Median band on carapace densely clothed with silvery-white hairs, which extend to each posterior lateral eye; on each side of this is a very broad band of more scattered reddish hairs; lateral margins of thorax with a band (or series of triangular patches) of white hairs; anterior surface of head clothed with white and reddish hairs intermixed.

Anterior median *eyes* small, about 2 diameters apart, and a little more than a diameter from the posterior median eyes; these eyes large, a little more than twice as wide as an anterior median eye and nearly $1\frac{1}{2}$ diameters apart; lateral eyes on each side subequal and larger than the anterior medians, each posterior lateral eye with a large white bristle overhanging it, the tubercle bearing the anterior laterals long; row formed by the anterior eyes much wider than that formed by the posterior ones.

Abdomen with a large conical process on each side above just before the middle and a smaller median one in front overhanging the thorax; integument covered for the most part with silvery-white hairs; posterior part of dorsal surface with a longitudinal, olivaceous, leaf-like band, which has wavy margins and is covered with reddish and some white hairs; anterior part with a longitudinal, median, olivaceous or black mark, which is dilated on each side behind into a long curved horn (reaching to the apex of the lateral tubercle), and is bordered posteriorly by a transverse ridge clothed with yellow hairs and joining the two tubercles; the median dark mark enclosed anteriorly by a horseshoe-shaped white mark covered with silvery hairs. Sides of abdomen with some olivaceous markings and a wavy line. Ventral surface clothed with ruddy and white hairs intermixed and marked with 4 white lunate spots, these spots densely clothed with silvery hairs and bordered externally by a longitudinal (sometimes indistinct) white line; median line darker. Vulva formed of a simple triangular plate acuminate in front, truncated behind, and slightly transversely dilated within the epigastric fold; a small brown stripe on lateral edge of plate present at each hind angle.

Chelicera with longitudinal bands of pale yellow and olivaceous, spotted with black on the distal half and furnished with 5–6 teeth in

the anterior and 4-6, besides, sometimes, some very minute ones, in the posterior row.

Labium blackened, with white apex. *Sternum* about ½ longer than wide, blackened (or yellowish and spotted with black), the median pale band clothed with white hairs, the lateral parts with reddish hairs.

Legs for the most part olivaceous or blackened, marked and banded with yellow; femora with a narrow yellow band at end of basal two-thirds (sometimes absent); tibia of third leg (and sometimes of first and second legs) in middle and of fourth leg near the base with yellow band; metatarsi of the 2 anterior pairs with 2 yellow bands or spots (sometimes absent or confluent), those of the 2 posterior pairs with a broad band in middle; tarsi pallid, at least at base.

♂ ♂. *Carapace* about ¼ as long as the first metatarsus, the median band on the thoracic portion narrower than in the ♀, the anterior median eyes larger, less than 2 diameters apart, and not more than a diameter from the posterior median eyes.

Abdomen more cylindrical, the anterior half of the dorsal surface differently marked, being provided with a large, triangular, longitudinal, yellowish or whitish area, which extends on each side behind to the apex of the dorsal tubercles, and is divided, at least posteriorly, by a dark median stripe without lateral horns; the yellow area bordered on each side by a broad dark band. Under surface of abdomen with broad median dark band bordered on each side by a narrower white stripe, the 4 lunate marks not differentiated.

Legs longer, olivaceous, the metatarsi mostly paler, the tarsi pallid, the 2 posterior pairs of metatarsi with a broad white band in middle, the other bands obsolete.

Pedipalps pallid at base, the distal part of femur and the 3 distal segments infuscated or black, the tibia clavate, the tarsus hemispherical, the palpal organ with a curved and flattened, claw-like (but not cruciform) lobe ascending from the centre of the coiled stylus.

Measurements.—Length of abdomen and carapace, ♀ 7, ♂ 6¾ mm.; length of carapace, ♀ 3⅓, ♂ 3, of first leg (from apex of coxa), ♀ 20, ♂ 32, of fourth leg, ♀ 12, ♂ 14¾.

Gen. MIAGRAMMOPES, O. P. Cambr.

Miagrammopes constrictus, n. sp.

1 ad. ♀ (No. 982) from Durban, Natal (*J. P. Cregoe*, October, 1896), resembling *M. brevicauda*, O. P. Cambr. (P. Z. S., 1882, pl. xxxi., fig. 12A), in general shape.

Carapace parallel-sided, evenly rounded in front, its length $1\frac{1}{2}$ times its width in the middle, its surface dark olivaceous-brown, yellowish at the anterior and lateral margins. The 4 principal eyes subequal, forming a slightly recurved row, the medians nearly twice as far from each other as from the lateral eyes and placed just behind the anterior fourth of the carapace, the lateral eyes placed in the centre of a broad low elevation.

Anterior pair of *legs* olivaceous, the sides of the femur and the sides and under surface of the tibia more or less yellowish, the sides of the tarsus and metatarsus reddish-yellow, the hair covering somewhat rubbed off, the short hairs white but the under side of the tibia and the upper and under sides of the metatarsus with a thick mane of longer white-tipped brown hairs; the three posterior pairs of legs pale yellowish, but the inner surface of second pair on the femur, of third pair on patella and distal part of femur and both inner and outer surfaces of patella and distal part of femur of fourth pair dark olivaceous or blackened.

Abdomen cylindrical, constricted near the anterior end, the caudal portion short, as in *brevicauda;* colour whitish or yellowish-white, the dorsal surface with a strong, blackish olivaceous, median band which widens posteriorly and spreads over the caudal portion, and is marked on each side with 3 small, deep black dots; anterior half of abdomen also with a dark dorsal mark on each side and a larger deep black mark in the lower part of the lateral surface; under surface with 2 narrow, dark, parallel, longitudinal lines; caudal portion, especially below, densely covered with fulvous hairs.

Sternum dark along the middle, yellowish laterally in the expanded portion.

Measurements.—Length of trunk (carapace + abdomen) 9 mm., of carapace $2\frac{1}{4}$, of abdomen $6\frac{3}{4}$; width of carapace in middle $1\frac{1}{2}$.

Family DICTYNIDÆ.

Gen. AUXIMUS, E. Sim.

1. Auximus schreineri, n. sp.

Specimens.—(**a**) 4 ♀♀, 3 ♂♂, and a number of young (Nos. 9460 and 11876) from Hanover, Cape Colony, collected by Mr. S. C. Cronwright Schreiner in 1901.

Closely resembling *A. capensis*, Poc., but with different vulva and with the pattern of yellow spots on the abdomen practically obsolete.

Carapace as long as the metatarsus and $\frac{2}{3}$–$\frac{3}{4}$ of the tarsus of first

leg in the ♀, and equal to the tibiæ but shorter than the metatarsus in the ♂.

Vulva.—Large excavation on the surface longer than broad, its bottom bordered on each side by a curved dark reddish band which terminates posteriorly in a large round black mark (Pl. X., fig. 1).

Tibiæ of 2 anterior pairs of *legs* with 3 pairs of spines below.

First leg in ♂ with the metatarsus a little longer than the tibia, bent slightly but rather suddenly inwards near end of basal $\frac{3}{5}$, and gently and slightly curved along the greater part of its length (the concavity below), and more sharply in the opposite direction at the base (the concavity above).

Length of carapace and abdomen, ♀ ♀ 9–13, ♂ ♂ 9–9½ mm.

(**b**) 2 ♀ ♀ from Willowmore (*Dr. H. Brauns*, 1903). Legs with fewer spines, the tibia of the first pair with only 2 pairs of spines below (the basal spines being absent), that of second leg with 1–2 basal spines.

2. Auximus silvaticus, n. sp.

Specimens.—2 ♀ ♀ and 1 juv. (No. 12797) from the forest at the Knysna (March, 1896, *W. F. P.*).

Resembling *A. capensis*, Poc., in general coloration, &c., but with much longer and slenderer legs and very different vulva.

♀ ♀. *Carapace* a little longer than the metatarsus of first leg; posterior median eyes further apart, being only a trifle nearer to one another than to the laterals.

Vulva a large, strongly convex, shiny plate, bearing a large, longitudinal, median groove anteriorly, and a transverse, blackish, ᔕ-shaped band (in a groove) on each side posteriorly (Pl. X., fig. 2).

Length of carapace and abdomen 14 mm.

3. Auximus longipes, n. sp.

Specimens.—(**a**) A number of ♀ ♀, ♂ ♂, and young from the Cape Peninsula (mostly found in the moister ravines on the slopes of mountains).

Differs from *A. capensis* and the 2 preceding species in having the sternum very broad and scarcely at all narrowed in front, and in other characters.

Carapace pale ochraceous to reddish-yellow, finely blackened at the edges, generally with a pair of infuscate marks on posterior part of cephalic portion, and occasionally with faint lateral infuscate marks on thoracic portion (often strongly marked in immature

specimens); its length considerably less than that of the first tibia or metatarsus in both sexes.

Abdomen infuscated, with a double series of transverse, whitish or yellowish stripes above extending more or less down the sides, the anterior pairs with a median white stripe running between them; under surface with a white line on each side. *Vulva* consisting of a hairy, yellowish, convex plate, more or less depressed in the middle and marked with a pair of thick infuscate bands, which converge anteriorly or form a **Λ**, the hind margin of the plate produced in the mesial part into a broad naked tongue, which is sharply grooved on each side of its surface (Pl. X., fig. 3).

Legs very long and slender, a little longer in the ♂ than in the ♀, the first metatarsus in the ♂ longer than the tibia and slightly curving upwards; colour pale ochraceous, frequently with infuscate bands (faint in the adult but strong in immature specimens), the distal segments reddish-yellow to dark reddish.

Pedipalps of ♂ very different from those of *A. capensis* and *schreineri;* patella short, truncated at right angles at distal end, its height almost equal to its length along upper surface; tibia much shorter than thick, the distal end deeply emarginate in the middle both above and below and above the middle on the inner side, the apical spur at the inner upper margin short and small, not produced beyond the level of the outer distal edge; tarsus large, much longer than the femur and than the patella and tibia together; stylus of palpal organ very long, forming a large **C**-shaped curve, over which is stretched a white membrane completely covering the under side of the tarsus (the stylus commences at the middle of the inner edge of the tarsus and ends a little behind its origin in a short, claw-like obtuse spur); outer edge of bulb with a short sharp spinous process in the middle (hidden under the tarsus).

Length of carapace and abdomen, ♀ ♀ $5\frac{3}{4}$–$10\frac{1}{2}$, ♂ $6\frac{1}{2}$ mm.

(**b**) 1 ♀ from the summit of the Hottentots Holland Mountains at Sir Lowry's Pass, Caledon Div. (*W. F. P.*).

(**c**) 1 ♀ and 1 ♂ from Lourensford, Hottentots Holland, Stellenbosch Div. (*H. Hermann*). Pedipalp of ♂ with the apical spur of tibia stouter and larger than in the types.

Gen. PSEUDAUXIMUS, E. Sim.

Pseudauximus pallidus, n. sp.

1 ♀ (No. 9461) from Hanover, Cape Colony (*S. C. Cronwright Schreiner*, October, 1901).

Colour like that of the palest specimens of *P. reticulatus*, Sim.

(Bull. Soc. Ent. Fr., 1902, p. 243), the abdomen being pale greyish, with a pair of infuscate lines near median line in front and a row of fainter, more lateral, infuscate marks on each side more posteriorly on dorsal surface, the sides and under surface with some scattered infuscate dots posteriorly; carapace and legs marked as in *reticulatus*.

Other characters also very similar except:

Tibia and metatarsus of *first leg* each with only 3 pairs of spines below and 1 other spine on the inner surface (the metatarsus sometimes with 3 and the tibia sometimes with only 1 apical spine).

Vulva a simple convex area with a large blackish mark on each side; the hind margin narrowly browned, emarginate in the middle (Pl. X., fig. 4).

Length of carapace and abdomen 6 mm.

Family ERESIDÆ.

Gen. STEGODYPHUS, E. Sim.

1. Stegodyphus canus, n. sp.

Specimens.—(**a**) 43 ♀ ♀ and 9 young (No. 3697) from Naroep, Great Bushmanland, Namaqualand Div. (*Max Schlechter*, March, 1898).

♀ ♀. *Colour.*—Carapace bright red, pale yellow behind and along the lateral borders, darker red on the lower part of the sides of the cephalic portion, the anterior edge narrowly blackened; whole carapace hoary with a thick coat of white or creamy-white hairs, except the facial portion below the level of the posterior median eyes, which is clothed with a triangular patch of yellowish-brown or golden hairs on each side of the median line, the two patches separated by a vertical wedge-shaped strip of white hairs; anterior edge with a thick fringe of white hairs. Chelicera red, thickly clothed with creamy-white hairs. Legs pale yellowish, the two anterior pairs more reddish, especially distally, all thickly covered with short white or creamy-white hairs, the 4 distal segments with black bands (often absent from the tarsi and metatarsi of the 2 anterior pairs), these bands covered with white or (especially in the fourth leg) with black hairs; fourth femur sometimes with a distal patch of dark hairs on inner and outer sides, and the coxæ and trochanters often with a group of fine black setæ below. Sternum reddish-yellow, with white hairs and a few fine black setæ, and generally marked with an infuscate submarginal line on each side. Abdomen pale yellowish, clothed

with short whitish hairs, practically unspotted above, with the exception of the stigmata and 2 clusters of small brown spots at anterior margin; the sides almost without spots or with a number of olivaceous spots; under surface variable, the middle area olivaceous, bordered on each side by a curved white band, and traversed longitudinally by 2 white stripes—or this area pallid, with the olivaceous hairs reduced to a small spot on each side; hairs on pulmonary segment pallid, black only immediately round the vulva.

Carapace as long as the tibia and $\frac{4}{5}$ or more of the metatarsus of first leg. Median eye-area decidedly narrowed in front, but the anterior eyes rather large, not much smaller than the posterior ones and larger than the anterior lateral eyes, which are placed on a large prominent tubercle.

Vulva a hard plate containing a large, deep, posterior cavity, which is bordered in front and at the sides by a high, thick, semicircular ridge; bottom of cavity containing a pair of lateral ridges converging anteriorly and bordered internally by a curved black groove, the median part occupied by a large brown lobe with a pair of convexities, the lobe separated from the black grooves by a narrow white ridge on each side (Pl. X., fig. 5).

Length of adult ♀ ♀ $13\frac{1}{2}$–18 mm.

(**b**) 2 ♀ ♀ and 1 juv. from Eities, Great Bushmanland, Kenhart Div. (*Max Schlechter*, March, 1898).

2. Stegodyphus tentoriicola, n. sp.

Specimens.—11 ♀ ♀ and 2 ♂ ♂ (No. 11836, &c.) from Hanover. A number of other specimens also from Hanover, Vlag Kop (5–6 miles north of Hanover), and Eierfontein (8–9 miles west of Hanover) (*S. C. Cronwright Schreiner*, 1902). Adult ♀ ♀ in February and March, ♂ ♂ in February.

♀ ♀ from Hanover. *Colour.*—Carapace covered with white hairs (the head in one specimen with yellow hairs); the thoracic portion nearly black, broadly reddish-yellow at the sides, the posterior and lateral margins narrowly blackened; the cephalic portion red or reddish-yellow behind, blackened on the sides anteriorly and on the upper part posteriorly, the upper part reddish again anteriorly; the region of the posterior lateral eyes reddish or reddish-yellow (connecting the posterior and anterior reddish patch on both sides) or black (connecting the posterior and anterior lateral black patches on each side); median posterior and anterior reddish patch also connected by a narrow reddish median line dividing the posterior black patch; face black, bisected by a median line of white hairs, usually

entirely covered with white hairs (replaced occasionally by black ones), and bordered on each side by a band of white (rarely yellow) hairs. Chelicera nearly black, covered with white hairs, except quite at apex, where the hairs are black. Sternum pale yellow or reddish-yellow, the sides broadly blackened, the hairs white, with a few black setæ. Legs pale yellowish, the 2 anterior pairs more reddish, all very strongly banded with black, the femora with a broad, intensely black, apical band, and one or two paler ones near the base, tarsi and metatarsi of 2 anterior pairs often darkened, the base of the metatarsi then yellowish or reddish-yellow; all or most of the coxæ and trochanters with black patches; the hairs on the legs white, those on some of the black bands black. Abdomen pale yellow, covered for the most part with yellow or cream-coloured hairs, without spots above, excepting the stigmata and generally also a few tiny black spots or groups of black setæ; the sides with a number of black spots and an inferior black patch (with black hairs); under surface with 2 large roundish or oval yellow marks posterior to the 2 pulmonary spiracles, and separated by a broad median black band, which is cleft anteriorly and clothed with black hairs; epigastric area black in the middle but yellow on the pulmonary opercula, these again often narrowly encircled with black, the hairs (except those immediately round the vulva) white; spinners black.

Carapace longer than patella and tibia and as long as the tibia and $\frac{5}{6}$, or nearly the whole of the metatarsus of first leg. Eyes much as in *S. canus*, n. sp., except that the anterior row of median eyes is wider, being not much narrower than the second row.

Vulva with the edge of the large cavity deeply emarginated in front, the cavity with a median keel and bounded behind by a curved ridge, which is notched in the middle; hind margin of the plate of vulva convexly projecting backwards beyond the hind margin of the epigastric area on each side of it (Pl. X., fig. 6).

♂ ♂. *Colour.*—Carapace much less densely hoary, often with some yellow hairs on each side on thoracic portion and yellowish-brown ones on the face; abdomen clothed above and on the upper part of the sides with rusty-red or brownish hairs, but the middle of the dorsal surface with a large, fusiform median band of pallid hairs; 2 anterior pairs of legs much less intensely banded, the bands being obsolete or almost so on the tibia above.

Carapace with the cephalic portion much higher and more abruptly defined, its length equal to the tibia and $\frac{1}{6}$–$\frac{1}{5}$ of the metatarsus of first leg.

Legs much longer, especially the anterior pair; tibia of first leg without fringe of long hairs, but the proximal black band clothed

with numerous minute, thick, black setæ (resembling spinules) on the side and below, but not above.

Tibia of *pedipalps* (measured along upper side) distinctly a little shorter than the patella and furnished with an external fringe of white hairs; the tarsus long, a little longer than the femur, clothed with short white hairs and longer black bristles.

Length of ♀ ♀ 10½–13 mm.; of ♂ ♂ 8–10 mm.

Habits.—According to Mr. Schreiner this species is never gregarious, for the females live singly, each in her own nest, being, however, sometimes accompanied by the male.

These nests, one of which was sent to me by Mr. Schreiner, are in the form of a hollow elongate cone, or "fool's cap," nearly 5 cm. in length, and formed of a closely woven inner lining, loosely covered externally by pieces of leaves and *débris* of insects. The nests are fixed on bushes.

Gen. ADONEA, E. Sim.

Adonea variegata, n. sp.

Specimens.—(**a**) 2 ♀ ♀ (Types: No. 3701) from Naroep, Great Bushmanland, Namaqualand Div., Cape Colony (*Max Schlechter*, March, 1898).

Colour.—Carapace and abdomen densely mottled with white and olivaceous hairs, the sides of abdomen with olivaceous spots, the dorsal stigmata each in the centre of a rather large white spot; posterior pairs of legs reddish-yellow, the anterior pairs darker, especially distally, all clothed with white and olivaceous hairs.

Carapace with the cephalic portion rather high (about the same height above the fovea as in *Eresus fumosus*, C. L. Koch), depressed, convex above and strongly sloping behind, its width much less than that of the thorax, and less than the length of the patella and tibia of first leg and than the distance from the fovea to the hind margins of the posterior median eyes. Posterior median eyes about 3 times as long as the anterior medians, and separated from the anterior margin by about their own diameter or less, from one another by about 1½ times this distance, and from the anterior lateral eyes by less than 3 diameters; width of posterior row of eyes about equal to the length of the oblique row formed by a posterior lateral eye and a posterior median eye of the opposite side.

Vulva a semicircular plate containing a large, deep, semicircular emargination, the bottom of which is occupied by a shallow subquadrate pan (Pl. X., fig. 7).

Under surface of tarsi and metatarsi and the apex of the tibiæ of

3 posterior pairs of *legs* spined, and also the tarsus and apex of metatarsus of first pair.

Length of carapace and abdomen 14–18 mm.

(**b**) 1 ♂ from Namies, Great Bushmanland, Kenhart Div. (*Max Schlechter*, March, 1898).

Carapace nearly black, but the upper part of the head dark reddish, the hair covering dark olivaceous, but the lateral margins of the thorax with a broad band of snow-white hairs; cephalic portion of carapace very much more suddenly and strongly elevated and more convex above than in the ♀, the hind surface rising almost perpendicularly from the fovea (but not overhanging it), the width exceeding that of the thoracic portion, about equal to the distance from the hind margin of head to the posterior median eyes, and almost equal to the length of the tibia and half the metatarsus of first leg. Posterior median eyes slightly smaller than in the ♀.

Abdomen covered with black hairs below and with creamy-white ones above, and furnished with a broad, fusiform, black mark occupying the space between the two rows of dorsal sagilla.

Legs longer and slenderer than in ♀, especially the 2 distal segments, the femur of first pair stouter than the others; reddish to almost black, with olivaceous hairs, but the dorsal surface of the patellæ, of the tibiæ, and, to a lesser extent, of the metatarsi clothed with white hairs, femora with an apical fringe of white hairs.

Pedipalps clothed with dark olivaceous hairs, the tarsus and palpal organ small.

Length of carapace and abdomen $10\frac{1}{2}$ mm.

(**c**) 1 ♀ from Kykgat, Great Bushmanland, Namaqualand Div. (*Max Schlechter*, March, 1898).

(**d**) 2 ♀ ♀ from the Bokkeveld Mountains about Nieuwoudtville, Calvinia Div. (*M. Schlechter*, August, 1897; *C. L. Leipoldt*, September, 1898). Width of head in these specimens less than or greater than the length of the first patella and tibia.

(**e**) 3 ♀ ♀ and 1 juv. from Touws River, Worcester Div. (*R. M. Lightfoot* and *W. F. P.*, August, 1903). Length of ♀ ♀ $9\frac{3}{4}$–15 mm.

(**f**) 1 ♀ from Matjesfontein, Worcester Div. (*W. F. P.*, August, 1903).

The nests of this species are constructed under stones.

Gen. SEOTHYRA, Purc.

Seothyra fasciata, n. sp.

1 ♀ (No. 12772) from the South-West Kalahari (*Dr. Eric Nobbs*, August, 1903). The nests of this species were seen in large numbers

along a considerable tract in Gordonia to the North-West of Uppington, between this town and the Molopo River.

Very like *S. schreineri*, Purc. (Ann. S. Afr. Mus., vol. iii., p. 32, 1903), but larger, and differing besides in the following respects :—

Colour of anterior legs more reddish-yellow, the distal segments red ; carapace reddish-yellow, the head orange-red ; abdomen with a row of transverse black patches on each side above, producing a transversely banded appearance, the short hairs between the bands yellowish.

Vulva with the anterior cavity very large, wider than the posterior portion of the median area, the median area transversely grooved both before and behind the constricted part, which is longitudinally grooved (Pl. X., fig. 8).

First *leg* apparently unspined, the tibia without a fringe of longer hairs on inner side, tibiæ II. and III. with a couple of apical spines below, IV. unspined.

Length of carapace and abdomen 8½ mm.

Nests.—The webs of two nests which were sent to me by Dr. Nobbs show that the nests of this species are constructed on the same plan as those of *S. schreineri*, Purc. (already described and figured, *loc. cit.*, pl. i., figs. 5–7), but on a much larger scale. A well-developed side-chamber is present, but it was not possible to distinguish the tongue-shaped flap at the entrance to the hole in the specimens at my disposal. The lobes of the lid are very much longer and narrower than those of *S. schreineri*, and according to Dr. Nobbs the sand is removed from the edge at the end of each lobe for a short distance to form a semicircular groove thus (‿), while between these 4 grooves the edges are not distinguishable. It is evident that in this species the spider crawls out from under the lid at the ends of the lobes only, and not all round the edges, as is the case in *S. schreineri*.

The nests were always found in the loose red sand of the desert.

Gen. DRESSERUS, E. Sim.

1. Dresserus angusticeps, n. sp.

2 ♀ ♀ (No. 11693) from Stompneus, St. Helena Bay, Malmesbury Div., collected by Mr. J. E. C. Goold in May and June, 1902.

Allied to *D. collinus*, Pocock (Ann. Mag. N. H., ser. 7, vol. vi., p. 323, 1900), from the Cape Peninsula, but differing in the following respects :—

Abdomen speckled with spots of white hairs above and lines of

white hairs at the sides, the dorsal stigmata also ringed with white, as in *Eresus fumosus*, Koch.

Carapace with the cephalic portion narrow and not so high as in *collinus*, the width of the head being equal to the tibia, metatarsus, and about $\frac{1}{5}$–$\frac{1}{6}$ of the tarsus of first leg, equal to or slightly shorter than the distance from the fovea to a line joining the hind margins of the posterior median eyes, but slightly less than the width of the thorax.

Eyes much as in *collinus*, the posterior medians perhaps a trifle smaller.

Vulva is in Pl. X., fig. 9, the posterior median portion rectangular, truncated, with a small cavity at each hind angle.

Legs short, the length of the carapace * being equal to the patella, tibia, metatarsus, and $\frac{1}{2}$–$\frac{3}{4}$ of the tarsus of first leg.

Length of carapace and abdomen 11 mm.

2. Dresserus laticeps, n. sp.

1 ♀ (No. 12831) from Tsabis, 20 miles N.E. of Concordia, Namaqualand Div., Cape Colony (*J. H. C. Krapohl*, 1902).

Carapace as long as the patella, tibia, metatarsus, and about $\frac{1}{5}$ of the tarsus of first leg, the cephalic portion reddish-black, very high and broad, flattened above, rising abruptly behind far above the height of the fovea, its width equal to the patella, tibia, and at least $\frac{1}{2}$ the metatarsus, and to the tibia, metatarsus, and $\frac{2}{3}$ of the tarsus of first leg, and considerably exceeding the distance from the fovea to the anterior margin of the ocular tubercle.

Posterior median *eyes* moderately large, about $1\frac{1}{2}$ diameters apart, their distance from the anterior laterals equal to 3 diameters at least.

Abdomen pale yellowish, covered with olive-brown hairs. Vulva as in Pl. X., fig. 10, the lateral emarginations rather shallow.

Length of carapace and abdomen 15 mm.

Family SICARIIDÆ.

Gen. LOXOSCELES, Lowe.

Loxosceles spinulosa, n. sp.

1 ♀ (No. 7915) from the Pass at Avontuur, near Stormsvlei, Swellendam Div. (*W. F. P.*, August, 1900).

* Length of carapace is measured between 2 parallel lines touching the anterior and posterior margins and includes the ocular tubercle.

Colour of carapace and limbs rufescent; abdomen very pale yellowish, covered with numerous reddish, setigerous granules.

Carapace broad, with very large longitudinal fovea; its length ½ that of first metatarsus; its surface clothed with long curved spines and smaller hairs and setæ, those on the thoracic region arranged in 6 radiating bands and a circumferential row at the extreme margin, the interspaces almost naked. Eyes rather large, the laterals not quite contiguous and rather far forward, a line touching the anterior edges of the anterior pair, passing only just behind the centres of the median eyes (when viewed from above); distance between a lateral and a median eye less than the width of a median eye.

Abdomen clothed with numerous fine hairs and setæ, the dorsal surface also with a number of curved spines, which are strongest anteriorly and become much slenderer posteriorly.

Legs very long and slender, bearing the scars of numerous spiniform setæ (mostly rubbed off); fourth leg longer than first.

Sternum with numerous long, curved spines and setæ.

Length 6 mm.; length of first leg (to base of femur) 18 mm.

Gen. SCYTODES, Latr.

1. Scytodes montana, n. sp.

Specimens.—(**a**) 1 ♀ (No. 12248) and several young from the top of Kalk Bay Mountain, Cape Peninsula (*W. F. P.*, February, 1902).

♀. *Colour* pale yellow. Carapace with five black stripes in middle part above, the median stripe narrow, running from anterior margin backwards and ending just in front of the highest point of the carapace; the black stripes next to the median one about twice as wide as the latter, almost parallel (only slightly converging posteriorly), extending from between the lateral eyes to the highest part of the carapace, and suddenly curving outwards at each end to unite with the outer stripes; these latter about twice as broad as those next to them, and extending from the anterior lateral angles of the clypeus over the lateral eyes to a little distance behind the highest part of the carapace; from the lateral eyes to the highest part these stripes bulge gently outwards, thus ( ), but behind this they diverge very slightly for a short distance and are truncated at the hind end; the 4 yellow stripes between the black ones narrow, equalling the median stripe in width. Sides of the carapace traversed by a narrow, horizontal black stripe, above which are 2 wavy stripes (or series of short stripes), transected by fine vertical lines and enclosing a row of 4 small yellow areas on each side; below the lowest encircling

stripe are a couple of short black stripes on each side. Abdomen spotted on anterior half and below, encircled in the middle by a transverse band (open below), behind which are a pair of dorsal dots and of lateral stripes, the posterior surface with a pair of vertical stripes; genital operculum blackened on each side. Sternum infuscated, with a row of 3 yellow spots on each side, an anterior and posterior yellow area and a median yellow stripe. Femora of legs faintly infuscated, not banded with black, the tips pale yellow; patellæ deeply infuscated; tibiæ like the femora but deeply infuscated at the tips; metatarsi and tarsi pale yellow.

Under side of *abdomen* with a pair of fine, not very distinct, brown ridges (visible when viewed from behind), which commence behind the lateral angles of the genital opening, strongly converge posteriorly, and are inturned at the hind ends and form the outer and posterior borders of a pair of oval light brownish areas (Pl. X., fig. 11).

Length of trunk (carapace and abdomen) $4\frac{1}{2}$ mm.

(**b**) 1 ♀ from the southern slopes of Table Mountain (*W. F. P.*, September, 1901), with much more black on the abdomen and on the sides of the carapace; the black stripe on each side of the median one united with the outer band by a transverse black bar at the anterior end of the ( )-shaped portion.

(**c**) 1 ♀ from Houw Hoek, Caledon Div. (*W. F. P.*), with the tibia of fourth leg marked with 3 distinct black bands; the black stripe on each side of the median one on the carapace fused in its middle portion for a considerable distance with the outer band.

2. Scytodes lycosella, n. sp.

1 ♀ (No. 8373) from Rietvlei, Umvoti District, Natal (*Harold A. Fry*, 1899).

Colour pale yellow. Carapace with only 3 black stripes above; the median one abbreviated behind, reaching only to the middle of the carapace; the outer stripes very broad, nearly meeting posteriorly, each containing an oval yellow spot just before the middle of the carapace; the median yellow area just behind the median black stripe broad and spindle-shaped; sides of the carapace with black reticulation and several tiers of yellow areas. Sternum with 4 ⅂-shaped marginal black marks on each side and 2 rows of dots in middle. Abdomen with numerous black markings. Legs very strongly banded, the femora with 3 strong black bands, the anterior pair also spotted with black near apex; patellæ black, paler above; tibiæ banded with black at base and apex and in the 2 posterior pairs

in the middle also, the 2 anterior pairs thickly spotted all over, the posterior pairs with a few spots only; metatarsi speckled with black, darkened at apex.

Brown horny plates on under sides of *abdomen* rounded, transversely oval, somewhat resembling those of *montana*, except that they are more distinctly bordered all round by a fine brown line and are further apart (Pl. X., fig. 12).

Length of trunk 5 mm.

3. Scytodes triangulifera, n. sp.

Specimens.—(**a**) 2 ♀ ♀ (No. 3917) from Prince Albert Village (*W. F. P.*, September, 1896).

Colour yellow. Carapace with a pair of very broad black bands above, resembling the outer bands of *S. montana*, but each provided in the broadest part at some distance behind the lateral eyes with a cuneate, oblique yellow spot or stripe, and with a smaller yellow spot at hind end; the median stripe reduced to a very short fine line between the lateral eyes and also in front of the median eyes; the median yellow band broad, but not so broad as the black bands; sides of the carapace with 2 stripes only, both, especially the upper one, strongly and angularly zigzag, and enclosing a series of yellow spaces on each side. Abdomen transversely striped, with 2 or 4 large spots above posteriorly. Sternum with 3–4 black spots on each side, the margins sometimes blackened. Femora of legs infuscated, with a paler band near the apex; the patellæ pale yellow above; the tibiæ pale, with dark band at base and apex and in the posterior pair in the middle also; metatarsi and tarsi yellowish.

Horny plates on under side of *abdomen* bearing each a very strong, well-marked, nearly straight, dark ridge running near outer margin of the plate from just behind the lateral angles of the genital opening and only slightly converging posteriorly, the edges of the ridges finely wavy, their hind ends far apart but slightly nearer together than the outer angles of the genital opening (Pl. X., fig. 13).

Length of trunk 8 mm.

(**b**) 1 ♀ from Willowmore (*Dr. H. Brauns*, 1904), with the abdomen banded at the sides only.

4. Scytodes leipoldti, n. sp.

2 ♀ ♀ (No. 3569) from Clanwilliam (*C. L. Leipoldt*, October, 1897).

Colour pale yellowish. Carapace with 4 black stripes above, the median stripe being entirely absent posteriorly to the median eyes,

and represented by a short stripe before these eyes; the inner stripes narrow, free and converging posteriorly, united a little in front of their middle by a thick transverse patch with the outer stripes and again at their anterior ends; the outer stripes not very thick; sides of the carapace with a black reticulation with large meshes. Abdomen with transverse rows of spots above and at the sides, the median line in front with 1–2 black marks. Femora of legs with 2 distal black bands, the more proximal band less distinct in the anterior pairs, which are also spotted at the sides; patellæ blackened at apex (except above); tibiæ with 3 black bands; metatarsi mostly darkened at apex. Sternum with 4 curved black marks on each lateral margin.

Horny plates on under side of *abdomen* very like those of *S. triangulifera*, n. sp., but the ridges slightly further apart and slightly more curved, thus ( ), rarely nearly straight.

Length of trunk 6 mm.

5. Scytodes flagellata, n. sp.

6 ♀ ♀ and 2 ♂ ♂ (No. 8322) from Houw Hoek, Caledon Div. (*W. F. P.*, August, 1900).

Colour pale yellowish. Carapace with the mesial yellow stripe strongly dilated (often lozenge-shaped) in the middle of the dorsal surface, and strongly constricted (sometimes even interrupted) posteriorly by the strongly approximated outer black bands; the median black stripe very narrow, reaching highest part of upper surface, and sometimes obliterated in the middle, the outer black stripes very broad, with jagged outer and concave inner margins, and containing several small yellow dots; lateral surface of carapace with black reticulation showing several tiers of yellow spaces. Sternum spotted, with 4 transverse black marks on each side, or the sides broadly blackened and each with a row of 3–4 yellow spots. Abdomen with transverse bands of black and speckled all over. Femora of legs numerously spotted and furnished with a distal black band, and generally also a more mesial one and a basal one; patellæ black distally; tibiæ with 3 dark rings, the mesial one fainter in the anterior pairs.

Horny plates on under side of *abdomen* with a pair of outcurved ridges remote from each other, the hind ends of the ridges outturned and a little nearer together than the front ends * (Pl. X., fig. 14).

* The distance between the ridges varies somewhat in different specimens, being relatively closer together in less distended abdomens. The same applies to the other species.

Process of *palpal organ* in ♂ in this and the following forms consisting of a thicker proximal and a slenderer distal portion. The proximal portion in this species slightly thickened at apex and considerably shorter than the very long, slender, lightly curved, distal portion; the length of the whole process much exceeding the entire length of the tarsus (Pl. X., fig. 15).

Length of trunk in ♀ 6½ mm., ♂ 5.

6. Scytodes arenacea, n. sp.

1 ♀ (No. 5363) from Beenbreek, near the Orange River, Kenhart Div., Great Bushmanland (*Max Schlechter*, August, 1899).

Colour very pale yellowish. Carapace with 3 black stripes above passing through the 3 groups of eyes, the median stripe narrow, reaching highest part of carapace, the outer stripes also narrow, only about twice as broad as the median stripe and remote from it; between the 3 stripes just behind the line of lateral eyes are 2 short fainter patches, representing the inner pair of lines; sides of carapace with a row of oval black rings (or 2 wavy lines), and above them a couple of infuscate spots. Sternum without markings. Femora of anterior legs with narrow distal band and a few spots of black; patellæ blackened at apex on each side; tibiæ blackened at apex and middle and in some at the base, but the third pair scarcely blackened at all; metatarsi slightly darkened at apex; abdomen with some small black dots above.

Horny ridges on under side of *abdomen* similar to those of *S. flagellata*, n. sp., but shorter.

Length of trunk 4⅘ mm.

7. Scytodes testudo, n. sp.

Specimens.—(**a**) 3 ♀ ♀ and 1 ♂ (No. 12079) from Lion's Hill, Cape Peninsula.

Colour pale yellow. Carapace with 5 black stripes down back, corresponding to those of *S. montana*, n. sp., the median stripe very narrow and generally more or less obliterated in its middle part but distinct posteriorly and for some distance before and behind the median eyes; the black stripe on each side of the median one also narrow, inturned at the free posterior end but united by a thick transverse black patch with the outer stripe at the anterior end of the very thick ( )-shaped part of the latter; sides of the carapace divided by the black reticulation into several tiers of yellow areas. Abdomen spotted and banded. Sternum with 4 ⅂-shaped marks

on each lateral margin, and 6 dots in 2 rows down the middle. Femora of legs yellow, with 2 black rings in distal part, the proximal part with numerous blacks dots in rows; patellæ black distally, yellow at base; tibiæ yellow, with 3 well-marked black rings; metatarsi and tarsi yellow, the former often darkened at apex.

Horny plates on under side of *abdomen* with a pair of strongly curved)(-shaped brown ridges, closer together than in *S. flagellata*, the anterior ends of the ridges diverging further apart than the posterior ends (Pl. X., fig. 16).

♂. *Palpal organ* about as long as the tarsus, the proximal portion of the process cylindrical, the slender distal portion very short and bearing at its base a small rounded laminate lobe, the length of the whole process less than that of the tarsus (Pl. X., fig. 17).

(**b**) Many other ♀ ♀ and ♂ ♂ from all parts of the Cape Peninsula. Some specimens have much more black than the types, the sternum being then thickly spotted and the abdomen almost entirely infuscated. Femora sometimes with a black band in front or behind at base. Length of ♀ up to 6½ mm.

(**c**) 1 ♂ and 2 ♀ ♀ from Stellenbosch (*L. Péringuey*).

(**d**) 1 ♂ and 1 ♀ from Lourensford, Hottentots Holland, Stellenbosch Div. (*H. Hermann*).

(**e**) 3 ♂ ♂ and 1 ♀ from Brandvlei, Worcester Div. (*W. F. P.*).

(**f**) 1 ♀ from Rabiesberg, near Nuy Station, Worcester Div. (*W. F. P.*).

(**g**) 1 ♀ from Houw Hoek, Caledon Div. (*W. F. P.*).

(**h**) 1 ♀ from Caledon (*Mrs. W. F. Purcell*).

(**i**) 1 ♂ and several ♀ ♀ from French Hoek (*W. F. P.*), with the femora strongly banded at the base.

Karroo variety.—In the following specimens the more proximal of the 2 distal black bands of the femur is absent in the first pair of legs and frequently also in the other pairs :—

(**j**) 3 ♂ ♂ and 9 ♀ ♀ from Kogmans Kloof (captured by my wife and myself).

(**k**) 2 ♂ ♂ and 7 ♀ ♀ from Avontuur and Stormsvlei, Swellendam Div. (*W. F. P.*), with the femora sometimes almost entirely blackened in the proximal two-thirds.

(**l**) 1 ♀ from River Zonder Einde, Caledon Div. (*W. F. P.*).

8. Scytodes gooldi, n. sp.

Specimens.—(**a**) 1 ♀ (No. 12839) and 1 ♂ (No. 11675) from Stompneus, St. Helena Bay, Malmesbury Div. (*J. E. C. Goold*).

Allied to *S. testudo*, n. sp., but more heavily blackened. Carapace

with 3 black stripes above, the median stripe narrow but well developed, of equal width throughout behind the eyes and bordered on each side by a still narrower, straight, yellow line ; the extremely broad, outer black bands with 2 pairs of yellow spots (one pair behind the lateral eyes and the other at the middle of the carapace). Sides of carapace as in *S. testudo*. Sternum black, with a median yellow patch and a row of yellow spots on each side in the ♀, but more like that of *S. testudo* in the ♂. Legs heavily banded with black and yellow, the femora with 3 black and 3 yellow bands but not spotted at the base, which is black, the apex being yellow; patellæ black ; tibiæ with 3 black bands ; metatarsi with 3, mostly faint, infuscated rings ; tarsi pale yellow. Abdomen thickly covered with black markings.

Horny plates on under side of *abdomen* triangular, their inner angles provided with a pair of angular **><**-shaped ridges (Pl. X., fig. 18).

Palpal organ of ♂ very like that of *S. testudo*, but the distal laminate lobe very thin and transparent, only seen with difficulty. Length of whole palpal organ a little exceeding that of the tarsus.

Length of trunk in ♀ 5 mm.

(**b**) 1 ♂ from the mountain-side at St. James, Cape Peninsula (*W. F. P.*).

9. Scytodes subulata, n. sp.

3 ♀ ♀ and 2 ♂ ♂ (No. 12838, &c.) from Stompneus, St. Helena Bay, Malmesbury Div. (*J. E. C. Goold*).

Allied to *S. testudo*, n. sp.

Colour pale yellowish, the markings closely resembling those of *S. leipoldti*, n. sp., except that on the carapace the posterior half of each inner stripe is separated off from the anterior half (which often ends free) just behind the transverse bridge which joins the outer and inner stripes, while the femora of the legs are not spotted but provided with a very distinct basal, mesial, and distal black band. The inner stripes on the carapace are situated close to the outer stripes.

Horny plates on under side of *abdomen* resembling those of *S. testudo*, but with the ridges often somewhat more angularly bent.

Palpal organ of ♂ resembling that of *S. flagellata*, n. sp., but the slender distal portion shorter, equalling the subcylindrical proximal portion in length, the length of the whole process subequal to the length of the tarsus ; the anterior keel at base of distal portion very slender and transparent, scarcely visible.

Length of trunk in ♀ $5\frac{3}{4}$ mm.

10. Scytodes lyriformis, n. sp.

5 ♀ ♀ and 1 ♂ (No. 11816) from Hanover (*S. C. Cronwright Schreiner*, 1901).

Colour pale yellowish. Carapace with 5 black stripes above, but the median stripe short, continued only a little distance behind the median eyes; the inner of the paired strips narrow, subparallel, somewhat remote from the outer stripes and connected before their middle with the latter by a transverse bridge, and often again at the outcurved anterior ends, the posterior ends converging and free; outer stripes not very broad; sides of the carapace with a row of 4 black-bordered yellow areas on each side and with black marks above and below these. Abdomen pale yellow, with transverse black stripes and rows of spots. Sternum with 4 curved, marginal black stripes on each side and 3 pairs of black spots near the centre. Femora of legs striped longitudinally with rows of spots and black lines (sometimes absent in fourth pair), the distal part with 2 black bands; patellæ blackened at apex (except above); tibiæ with black mesial and distal bands, the anterior pairs also with a basal band; metatarsi darkened at apex.

Horny plates on under side of *abdomen* with the ridges curved as in *S. testudo* and *S. flagellata*, n. spp., their distance apart being less than in the latter but somewhat greater than in the former species.

Palpal organ of ♂ resembling that of *S. subulata*, n. sp.

Length of trunk in ♀ 6 mm.

This species scarcely differs in structure from *S. subulata*, n. sp., and may perhaps be merely a colour variety.

11. Scytodes karrooica, n. sp.

3 ♀ ♀ (No. 12872) from Matjesfontein, Worcester Div. (*W. F. P.* August, 1903).

Very like *S. lyriformis*, but larger in size, and with the horny ridges on the under side of the abdomen nearer together and longer (Pl. X., fig. 19).

Length of trunk 6½–7 mm.

12. Scytodes silvatica, n. sp.

Specimens.—(**a**) 2 ♀ ♀ and 1 ♂ (Types: No. 855) from the Knysna Forest (*W. F. P.*, March, 1896). Also 2 other ♀ ♀ with cocoons from the same locality.

Colour a deep brown or purplish-black, mottled with yellow Carapace with well-developed median stripe lying between a pair

of broader yellow stripes, on each side of which is a very broad, curved, black band, the latter bearing a small yellow spot just before the middle of the carapace; sides of carapace broadly blackened inferiorly, with a row of 4 yellow spots on each side and a row of larger or smaller, more irregular yellow marks above these; posterior part of carapace with median yellow spot. Abdomen with transverse yellow stripes, the under side often yellow. Sternum usually with 3 paler, transverse, marginal marks on each side. Femora of posterior legs with 2 distal yellow bands; patellæ yellowish at base; tibiæ of posterior legs generally with 2 yellowish bands; metatarsi variable, the posterior pairs being generally pale yellowish and the anterior pairs infuscated and with or without 2 yellow bands.

Horny plates on under side of *abdomen* of ♀ and the *palpal organs* of ♂ much as in *S. lyriformis*, n. sp.

Total length of trunk in ♀ 6½ mm.

In the 2 ♀ ♀ with cocoons almost the whole animal, with the exception of the 2 distal leg-segments and the 2 submedian yellow stripes, is dark brown.

(**b**) 3 ♀ ♀ from Port Elizabeth (*J. L. Drège, J. P. Cregoe*) in which the legs are without yellow bands and are paler and more yellowish from the tibia on; the tibiæ generally infuscated at base and apex.

13. Scytodes caffra, n. sp.

1 ♀ (No. 9933) from Zululand (*W. Anderson*).

Colour.—Carapace black, the anterior two-thirds with a median yellow stripe containing a narrow, median black line which almost reaches to middle of carapace; posterior surface of carapace with median yellow patch; sides with 4 tiers of rather small yellow spots. Abdomen transversely striped with black and yellow. Sternum black, with a posterior, an anterior, and 3 pairs of lateral yellow spots. Femora of legs infuscated, yellowish at the base above and, in the posterior pairs, also behind; patellæ yellowish above; tibiæ yellowish, but infuscated at base and apex; metatarsi yellowish, darkened at the base.

Horny plates on under side of *abdomen* with a pair of strong curved ridges. (In the type one ridge is more angularly bent than the other.) (Pl. X., fig. 20.)

Length of trunk 9½ mm.

14. Scytodes cedri, n. sp.

1 ♀ (No. 4255) from Keurbosch Kraal River, Cedarberg Range, Clanwilliam Div. (*R. M. Lightfoot*, August, 1898).

Colour.—Carapace with the well-developed, median black stripe reaching to highest part of dorsal surface and lying between 2 still narrower, parallel yellow stripes, which extend from behind the median eyes to the hind margin and unite to a single stripe behind the median black stripe; on each side of the yellow stripe is a very broad black band with practically straight inner and strongly sinuous outer margins, and containing a longitudinal yellow spot in the middle; sides of the carapace with a network of thick black lines enclosing several tiers of yellow markings and uniting above with the broad black bands. Abdomen pale yellowish, apparently hardly spotted at all. Sternum yellow, with some dots and lateral marginal lines. Legs infuscated, the distal segments paler, the tibiæ darkened at base and apex, and the posterior ones with mesial band as well.

Horny plates on under side of *abdomen* with a pair of longitudinal ridges, which almost touch the median line and then suddenly bend outwards almost at right angles in front (Pl. X., fig. 21).

Length of trunk 5 mm.

15. Scytodes lanceolata, n. sp.

2 ♂ ♂ (No. 9471) from Hanover (*S. C. Cronwright Schreiner*, 1901).

Colour pale yellowish. Carapace with 3 black stripes above, the median yellow stripe rather broad, the median black stripe very fine posteriorly and not reaching behind the middle of the carapace, the outer black stripes broad, each with a longitudinal series of 3 or 4 yellow spots or stripes; sides of carapace reticulated with black, showing several tiers of yellow spaces. Abdomen with transverse black bands and rows of spots, the under side black-spotted. Sternum with 4 pairs of marginal black lines and 2 central rows of dots. Femora of legs with black bar at apex, the anterior surface, at least in the anterior pairs, also sprinkled with black; tibiæ sparsely sprinkled with black, the apex with a black band; patellæ blackened below.

Palpal organ about as long as the tarsus; the process compressed and lanceolate distally, the short apical part subulate, with sigmoid curvature and with slender keel in front (Pl. X., fig. 22).

Length of trunk $4\frac{3}{4}$ mm.

16. Scytodes elizabethæ, n. sp.

2 ♂ ♂ (No. 5665) from Port Elizabeth (*J. L. Drège*, November 1899).

Colour pale yellowish. Carapace with 3 black dorsal stripes, the

yellow lines separating them narrow, straight, and parallel, passing anteriorly round the median eye-tubercle, the median stripe well developed, reaching highest part of dorsal surface, the lateral stripes broad and provided each with 2 more or less distinct yellowish spots near the middle; sides of carapace with a series of black-bordered spaces in 1 or 2 tiers. Sternum with 4 marginal infuscate marks on each side and a few more central dots. Abdomen with transverse black bands and rows of spots. Femora of legs infuscate at apex and sometimes faintly so nearer the middle, the anterior pair faintly infuscate along anterior and posterior surfaces; patellæ infuscate, pallid above; tibiæ darkened at apex and often also at base.

Palpal organ a little longer than the tarsus, which is about equal to the process in length; the process broadened distally, with a strong brownish keel on inner side, the short apical portion with very strong sigmoid curvature (Pl. X., fig. 23).

Length of trunk 5 mm.

Synopsis of the South African species described above * :—

♀ ♀.

a. Horny plates behind vulva on under side of abdomen with a pair of rectangularly bent ridges, which almost touch in the median line (fig. 21). Clanwilliam Div. *S. cedri*, n. sp.

b. Horny plates not almost touching in the median line.

a^1. Horny plates on under side of abdomen with the ridges straight or incurved or circular.

a^2. Horny plates with a pair of very strong \ /- or ( )-shaped ridges.

a^3. Carapace with a single, very broad black band on each side of the median yellow stripe above. Prince Albert, Willowmore. *S. triangulifera*, n. sp.

b^3. Carapace with 2 much narrower, curved black stripes on each side of the median yellow stripe. Clanwilliam .. .. *S. leipoldti*, n. sp.

b^2. Horny plates oval, bordered by very weak ridges.

a^4. Femora of legs not banded. Cape and Caledon Divs. *S. montana*, n. sp.

b^4. Femora of legs strongly banded with black and yellow. Umvoti Distr. (Natal) .. .. *S. lycosella*, n. sp.

b^1. Horny plates with a pair of well-marked, outcurved ridges, thus) (.

a^5. Femora of legs (at least some of them) more or less speckled with black, the dots generally forming rows.

a^6. Horny ridges on under side of abdomen far apart (fig. 14).

a^7. Femora yellow, with only a few dots and a feeble distal black band. Great Bushmanland .. .. *S. arenacea*, n. sp.

b^7. Femora thickly spotted and provided with strong distal black band. Caledon Div. .. .. *S. flagellata*, n. sp.

b^6. Horny ridges nearer together (figs. 16 and 19).

* The only other South African species which have been described are *S. broomi* from Namaqualand and *S. marshalli* from Estcourt (Pocock, Ann. Mag. N. H., ser. 7, vol. x., pp. 321–323, 1902). Both are unknown to me.

a^8. Median black stripe on carapace reaching to highest part of upper surface, although sometimes interrupted in the middle. Cape, Stellenbosch, Paarl, Caledon, Worcester, Robertson, and Swellendam Divs. .. .. *S. testudo*, n. sp.

b^8. Median black stripe strongly abbreviated behind, ending before the middle of the carapace.

a^9. Larger. Horny ridges on under side of abdomen nearer together (fig. 19). Matjesfontein .. .. *S. karrooica*, n. sp.

b^9. Smaller. Horny ridges further apart. Hanover. *S. lyriformis*, n. sp.

b^5. Femora not speckled.

a^{10}. Femora of anterior legs strongly banded with black and yellow.

a^{11}. Black median stripe on carapace well developed, reaching to highest part of dorsal surface. Cape and Malmesbury Divs. *S. gooldi*, n. sp.

b^{11}. Black median stripe obsolete posteriorly to the median eyes. Malmesbury .. .. *S. subulata*, n. sp.

b^{10}. Femora of anterior legs infuscated.

a^{12}. Length about 9½ mm. Zululand .. .. .. *S. caffra*, n. sp.

b^{12}. Length about 6½ mm. Knysna and Port Elizabeth. *S. sylvatica*, n. sp.

♂ ♂.

a. Distal portion of process of palpal organ filiform, very long and slender, much longer than the slightly clavate proximal portion. Caledon. *S. flagellata*, n. sp.

b. Distal portion of process not or scarcely longer than the proximal portion.

a^1. Slender distal portion of process of palpal organ subulate, about as long as the subcylindrical proximal portion.

a^2. Femora yellow, banded with black but not speckled. Malmesbury. *S. subulata*, n. sp.

b^2. Femur yellow, speckled at base, banded distally. Hanover. *S. lyriformis*, n. sp.

c^2. Femora infuscated. Knysna .. .. *S. silvatica*, n. sp.

b^1. Slender distal portion of process much shorter than the thicker proximal portion.

a^3. Process of palpal organ straight, the proximal portion not thickened distally.

a^4. Process of palpal organ with a small but conspicuous keel in front at base of distal portion. Femora speckled. Cape, Stellenbosch, Worcester, Paarl, Robertson, Swellendam .. .. .. *S. testudo*, n. sp.

b^4. Process with the anterior distal keel very slender and scarcely distinguishable. Femora not speckled. Cape and Malmesbury. *S. gooldi*, n. sp.

b^3. Process of palpal organ not straight.

a^5. Distal portion of process lightly sinuous (fig. 22). Hanover. *S. lanceolata*, n. sp.

b^5. Distal portion very strongly sinuous (fig. 23). Port Elizabeth. *S. elizabethæ*, n. sp.

Gen. DRYMUSA, E. Sim.

1. Drymusa silvicola, n. sp.

Specimens.—2 ♀ ♀, 1 ♂, and 3 juv. (No. 871) from the forest at Knysna (*W. F. P.*, March, 1896).

♀ ♀ . *Colour* of carapace and limbs reddish-brown, the ends of the legs pale yellowish, the upper side of the patellæ, the apex and base of the tibiæ and the base of the metatarsi also more or less yellowish; carapace with 2 black marks at middle above, which converge posteriorly and emit from each side 3 wavy, black, radiating lines, and from the front 6 subparallel lines, the latter anastomosing anteriorly on the head.

Anterior median *eyes* a little larger than the laterals and situated slightly in front of the line joining the anterior margins of the anterior lateral eyes. Clypeus a little exceeding twice the length of a median eye.

Abdomen narrow oblong, shortly acuminate at apex. Epigastric area very long, entirely covered below by a very large, brown, smooth, semicylindrical, somewhat fiddle-shaped plate extending from anterior end to middle of under surface of abdomen, and occupying the whole space between the pulmonary opercula, whose stigmata lie a little before the middle of the plate; anterior end of plate strongly emarginate, the edges strongly reflexed on each side of the emargination; hind end of plate sinuated in the middle, the sinus closed by a small, hard brown plate placed vertically behind the genital opening, and itself emarginate in the middle of its lower edge (Pl. XI., fig. 24).

♂ . *Pedipalps* with the 3 distal segments nearly pallid, turgid, the femur darker, much slenderer, cylindrical; tarsus subglobular, very broad, appearing, when seen from above, transverse and sinuate in the middle at apex, covered with long hairs on upper and inner surfaces; bulb small, globular, the spine strong, much curved distally, and pointed at apex (Pl. XI., fig. 25).

Length of ♀ ♀ $8\frac{1}{2}$–$9\frac{1}{2}$, ♂ $6\frac{3}{4}$ mm., of carapace in largest ♀ 4, ♂ 3, of first leg (to base of femur) in ♀ $33\frac{1}{2}$, in ♂ 35.

Young coloured much as in the adult, the abdomen without yellow transverse stripes.

2. Drymusa producta, n. sp.

Specimens.—3 ♀ ♀ (No. 7905) from the forest on the mountain-side at Swellendam (*W. F. P.*, August, 1900).

Colour not quite so dark as in the preceding species, the legs much more yellowish in the distal half at least, the abdomen marked above with about 3 pairs of yellow spots in the middle part, followed behind by indications of fine, yellow, transverse lines.

Clypeus about equal to twice the length of a median eye.

Abdomen like that of the foregoing, but the hardened brown plate before the genital opening much smaller, not reaching anterior end of abdomen, although extending backwards to or nearly to the middle

of the ventral surface, the plate somewhat saddle-shaped, the anterior part not raised and gradually passing over into the soft integument, the hind part distinctly hardened and browned, emarginate in the middle of hind margin, with transverse cluster of short setæ. No differentiated plate posterior to genital opening (Pl. XI., fig. 26).

Length $7\frac{1}{2}$, of carapace $3\frac{1}{2}$, of first leg $26\frac{1}{2}$ mm.

The adult ♀ ♀ of the 3 South African species may be distinguished as follows :—

a. Vulva placed far forward, the epigastric area not produced backwards in the middle below, where its hind margin is broadly sinuated, the sinus touching a line joining the hind ends of the pulmonary spiracles. Cape Peninsula.
D. capensis,* E. Sim.

b. Vulva placed at or near middle of ventral surface of abdomen, the epigastric area very strongly produced backwards in the middle below far behind the spiracles, the posterior part at least being hardened to form an epigynum.

*a*¹. Plate of vulva very large, reaching anterior end of abdomen ; vulva closed behind by a small, transverse, vertical sclerite. Knysna. *D. silvicola*, n. sp.

*b*¹. Plate of vulva much smaller, not reaching anterior end of abdomen ; the vulva without additional posterior sclerite. Swellendam.
D. producta, n. sp.

Family DYSDERIDÆ.

Gen. ARIADNA, Aud.

1. Ariadna dentigera, n. sp.

1 ♀ (No. 8600) from the side of Table Mountain above Newlands (*W. F. P.*, August, 1900).

Colour.—Carapace dark reddish-brown, paler behind but almost black anteriorly, with iridescent sheen, the margins finely blackened; chelicera black, with strong iridescent sheen (in spirits) ; abdomen pale fulvous yellow below, brown between the pulmonary opercula, the dorsal surface dark violaceous ; legs and sternum reddish-ochraceous, the anterior legs slightly more reddish distally but without dorsal markings, the sternum brown at the margins, iridescent, darker in the strong, intersegmental, lateral depressions.

Carapace as long as the tibia and $\frac{3}{4}$ of the metatarsus of first leg, very broad in front, its width just behind the ocular area almost equalling the length of the first tibia. Ocular area wide, the distance between the median and posterior lateral eyes slightly exceeding the width of the 2 median eyes together ; the eyes subcontiguous

* The type of this species was very immature, for the adult ♀, which is larger than either of the two new species, attains a length of $13\frac{1}{2}$ mm., the length of the first leg (from base of femur) being 47 mm.

in pairs, the posterior row with its hind margin forming a slightly recurved line, wider than the anterior row; the lateral eyes oval, subequal, longer than the rotund medians.

Legs longish, not stout, the fourth femur not thickened, equalling the first in thickness. The hairs mostly rather short and not dense. *Metatarsus* I. a trifle longer than the tibia, with a double outer and treble inner series of spines, the superior spines shorter; II. spined as in I.; III. with 1 posterior row of spines and an anterior band 3 rows deep; IV. with 1 inner and 3 outer rows, the middle outer row composed of 3–4 spines, the others mostly of 1 spine each, the transverse apical comb at inferior inner edge composed of a single series of many long setæ of equal length and very close together. *Tibia* I. with broad inner and outer bands of stout spines, arranged in 3–4 irregular rows in each band (16–17 in inner and 12–13 in outer), the lowest spines not very long but longer than the others; the 2 inferior rows not very far apart; II. with about half as many spines in the bands, the spines 2–3 deep in each band; III. with 1 anterior and 3 posterior rows; IV. with 3–4 inferior outer, 1 inferior inner, and 2 superior inner spines. *Patella* III. with 1 anterior upper spine, the rest unspined. *Femora* with 2 (rarely 3) dorsal spines and 1 distal inner spine, the latter absent only in the fourth pair.

Inner margin of *chelicera* with 3 teeth in the upper row and with a single inferior apical tooth in addition, the latter very distinct and as strong as the others.

Length of abdomen and carapace 13½, of carapace 5⅔ mm.

2. Ariadna lightfooti, n. sp.

1 ♀ (No. 12903) from Hermanuspetersfontein, Caledon Div. (*R. M. Lightfoot*, February, 1902).

Colour.—Carapace pale yellowish, with black hairs, lightly infuscated at the sides posteriorly, the margins finely blackened. Legs pale yellowish, the femora, patellæ, and tibiæ more or less infuscated on the sides, the infuscation darkest on the 2 anterior pairs, especially on the femora (which are longitudinally banded with yellow), but very faint on the posterior pairs, the upper surface of the femora and of the anterior tibiæ also faintly infuscated along the middle line. Cheliceræ yellowish. Abdomen purplish-black, with narrow yellow line on each side, the epigastric area, excepting the black transverse patch in front of vulva, pallid. Sternum black. Labium and coxæ pale yellowish, narrowly blackened at the tips.

Carapace only a little shorter than the tibia and metatarsus of first

leg, narrowed in front, its width just behind the ocular area about $\frac{4}{5}$ of the length of the first tibia. Ocular area much as in *dentigera*, n. sp., but the distance between the posterior laterals and the medians subequal to the united width of the latter.

Legs relatively shorter, and, especially the first tibia and fourth femur, stouter than in *dentigera*, the fourth femur being distinctly a little thicker than that of first leg; also, the anterior legs especially, more densely clothed with black hairs. *Metatarsus* I. a little longer than the tibia, I. and II. with a single series of stout spines on each side, II. with an additional inner spine above the inner row near base; III. with 1 posterior and 3 anterior rows of 2–3 spines each; IV. with 1 basal and 1 apical outer spine only, the apical tuft composed of 6 setæ. *Tibia* I. with 3–4 rows of spines (7–8 in the lowest row and 5–8 in the others together) on each side, the 2 inferior rows very far apart; II. with 2 rows on each side and often a single additional spine between the rows, the inner rows each of 5 spines, the lower row abbreviated at base, the outer rows of 3–5 (upper) and 8–9 (lower) spines; III. with 1 anterior and 3 posterior rows; IV. unspined. *Patellæ* unspined. *Femora* I. and II. with 4–5, III. with 2, IV. with 0–2 medio-dorsal spines, I. also with 3 (in 2 rows), II.–III. with 2 and IV. with 0–1 inner distal spines, I. and II. besides with 1–2 outer distal spines.

Chelicera with 3 superior and 1 tiny inferior tooth.

Length 11, of carapace 5 mm.

3. Ariadna jubata, n. sp.

2 ♀ ♀ (No. 12830) from Tsabis (in Bushmanland), 20 miles north-east of Concordia, Namaqualand Div. (*J. H. C. Krapohl*, 1902). Allied to *lightfooti*, n. sp.

Colour.—Carapace light brown, the cephalic portion darkened on each side in front, veined with black posteriorly in one specimen. Chelicera dark reddish-brown. Posterior pairs of legs pale ochraceous, not at all or only faintly infuscated, the anterior pairs reddish-yellow or reddish, infuscated at least on the under surface and on distal part of inner surface of femora and on distal part of upper side of tibiæ along the median line. Abdomen purplish-black, with narrow lateral yellow line, or the lateral and ventral surfaces almost entirely pallid but with a pair of purplish marks posteriorly below. Sternum and labium brownish-yellow, the latter dark brown on each side.

Carapace as long as the tibia and nearly $\frac{3}{4}$ of the metatarsus of first leg, narrowed in front, its width just behind the ocular area about

$\frac{3}{4}$ of the length of the first tibia. Ocular area narrower than in *lightfooti*, the posterior lateral eyes being separated from the medians by a space subequal to the width of one of the latter eyes.

Legs.—Fourth femur thicker than the first; anterior pair of legs thickly clothed with long olive-brown hairs on the patella, tibia, and metatarsus, forming a thick mane, particularly on the upper side, the first tibia thick, its width subequal to the space between the posterior lateral eyes. *Metatarsus* I. as long as the tibia; I. and II. with a single series of spines on each side below; III. with 2 anterior and 2 posterior rows of 2–3 (rarely 1) spines each; IV. with 1 apical and 0–1 basal spine below and 3–4 setæ in the apical comb. *Tibia* I. with 5–7 spines in each inferior row, besides 3–4 others on each side; II. with 3 spines on each side above the inferior row; III. with 1 anterior and 2 posterior rows; IV. unspined. *Patella* I. with 1 outer and 1–2 inner spines; II. and III. also spined on one or both sides. *Femora* I.–III. with dorsal, inner distal, and generally also outer distal spines, the inner distal spines on I. numerous, 7–9 in number, and placed in 3 rows; IV. unspined.

Chelicera without distinguishable inferior tooth.

Length $9\frac{1}{2}$ mm.

4. Ariadna kolbei, n. sp.

1 ♀ (No. 5316) from the Kentani District, Transkei (*Rev. F. C. Kolbe*, 1899).

Colour.—Carapace dark reddish-brown, very dark anteriorly. Chelicera black. Posterior legs rufescent, the anterior legs reddish, the first pair dark red, with lighter patella. Abdomen pallid, suffused with dark purplish above, especially posteriorly. Sternum yellowish-brown. Labium dark brown.

Carapace as long as the tibia and $\frac{3}{4}$ of the tarsus of first leg, its width behind the ocular area $\frac{3}{4}$ of the length of first tibia. Ocular area much as in *lightfooti*, n. sp.

Legs much as in *lightfooti*, except: *Metatarsus* I., if anything, a trifle shorter than the tibia, IV. with about 8 setæ in the comb; *tibia* I. with 6–8 spines in the lower rows and 3–4 in each upper row, II. with 9–11 outer and 4 inner spines below and 4 inner and 2 outer more superior spines, III. with 1 inferior row of 3–4 and 1 anterior upper row of 2 spines; *patella* I. with strong inferior inner spine; *femora* each with about 4 medio-dorsal spines, otherwise as in *lightfooti*.

Chelicera as in *lightfooti*.

Length $14\frac{1}{4}$, of carapace $7\frac{1}{4}$ mm.

5. Ariadna bilineata, n. sp.

Specimens.—(**a**) 4 adult ♀ ♀ (Nos. 3443, 3532, &c.), several with cocoons, from Signal Hill and the slopes of Devil's Peak (*R. M. Lightfoot, W. F. P.*), and a number of others, apparently immature, also from the Cape Peninsula.

♀ ♀. *Colour.*—Carapace reddish-yellow to dark reddish-brown, sometimes nearly black anteriorly, the margins finely blackened, the surface hairy and usually finely veined with black, the posterior part of the cephalic portion generally finely outlined in black. Chelicera yellowish-red to black. Abdomen with a fine, pale yellowish line running from end to end down middle of each lateral surface, the dorsal surface violet-black, generally with several very fine, transverse, arcuate, yellowish lines posteriorly, the ventral and lateral surfaces (below the lines) either violet-black (except the pulmonary opercula and a pale yellowish patch on each side posteriorly) or pale yellowish, with a pair of posterior black patches below, a black patch between the lungs and an anterior black area on each side. Legs faintly or strongly infuscated, the 2 anterior pairs darker than the posterior ones, the femora with 2 upper and 1 outer pale yellow stripe, the outer stripe on fourth leg very short, basal; patellæ pale yellowish, infuscated distally; tibiæ with 2 widely separated, superior, yellowish stripes; metatarsi and tarsi paler than the tibiæ and femora, the metatarsi nearly all blackened at apex, at least on inner side. Sternum reddish-yellow, lightly infuscated, the lateral margins and depressions generally much blackened. Labium darkened at base.

Carapace as long as the tibia and about $\frac{2}{3}$ of the metatarsus of first leg, narrowed in front, its width just behind the eyes only about $\frac{3}{4}$ of the length of the first tibia, its surface sparsely hairy. Ocular area rather narrow, the distance between the posterior lateral eyes and the median eyes being less than the united width of the latter, the hind margin of the posterior row forming a straight or slightly recurved line.

Legs clothed with brown hairs, the hairs on anterior tibia neither long nor very dense; fourth femur slightly thicker than the first, the first tibia not much thickened. *Metatarsus* I. a little shorter than the tibia; I. and II. with a single outer and inner row of stout spines below; III. with 2 inferior rows of spines, besides an outer and an inner row of 1–2 spines each; IV. with a slender apical and sometimes a basal spine below, the apical tuft composed of 4–7 setæ. *Tibia* I. with an outer and an inner row of 6–9 stout spines each below, in addition to an outer and an inner row of 3 (rarely 2) spines

each on the sides; II. spined much as in I., except that the inner row is composed of fewer spines than the outer; III. with an anterior row of 0–2 and 2 posterior rows of 2–4 spines each; IV. unspined. *Patellæ* not spined. *Femora* I.–III. with a medio-dorsal row of several spines and an outer distal row of 1–2 spines, I. also with an inner distal group of 3–4 spines; II. and III. with 1–2 inner distal spines; IV. unspined.

Chelicera with the lower tooth obsolete or scarcely distinguishable.

Length of carapace and abdomen $5\frac{1}{2}$–$7\frac{1}{2}$ mm.

This is the smallest and at the same time the commonest of the 3 species found in the Cape Peninsula. In the apparently immature specimens the legs are pale yellow, with much less or even scarcely any infuscation, which is often limited to the tips of the segments of the anterior legs.

(**b**) 1 ♀, with cocoon, from the Hottentots Holland Mountains above Gordon's Bay (*R. M. Lightfoot*).

(**c**) 3 ♀ ♀ from the Paarl (*R. M. Lightfoot*), with the sternum darkened and with median yellow stripe.

(**d**) 1 ♀ from Hermanuspetersfontein, Caledon Div. (*R. M. Lightfoot*).

(**e**) 2 ♀ ♀ from St. Helena Bay, Malmesbury Div. (*J. E. C. Goold*), with the abdomen much more yellow than in the types.

6. Ariadna karrooica, n. sp.

Specimens.—(**a**) A ♀ (No. 12902) and a ♂ (No. 12845) from Hanover and a ♀ (No. 11963) from Eierfontein, 8–9 miles west of Hanover (*S. C. Cronwright Schreiner*, 1901).

♀ ♀ (*Types*). Very like *bilineata*, but with stouter anterior tibiæ.

Colour of carapace and legs as in the darkest specimens of *bilineata*, but the anterior metatarsi dark reddish or almost black. Abdomen pallid, more or less suffused with purplish, at least on the dorsal and ventral surfaces, the middle of the epigastric area and sometimes a couple of posterior ventral patches dark purplish. Sternum and labium deep blackish-brown, the labium sometimes paler at apex.

Carapace as in *bilineata*, but the posterior row of eyes slightly wider and with its hind margin forming a slightly procurved line (seen from above).

Legs like those of *bilineata*, except that the anterior tibiæ are thicker and more densely clothed with long dark brown hairs; fourth

metatarsus with stout basal as well as apical spine below; tibia I. with 5–6 spines in each inferior row, besides 3–4 inner and 5–6 outer more superior spines, the latter in 2 rows, II. with 3 inner and 4–5 outer spines above the inferior row of 6–7 spines; patella I. with short internal spine; femur IV. with dorsal spines and sometimes also a distal internal spine.

Chelicera with the inferior tooth very minute, scarcely distinguishable.

♂. Resembling the ♀ ♀, but with the legs much longer, paler in colour and differently spined.

Carapace as long as the first metatarsus.

Legs.—Metatarsus I. sinuous, curving upwards at base and downwards at apex, as long as the tibia and a little more than ½ the patella, spines 3 on each side below and 1 on inner surface near base; II. with 3 spines on each side below and 1–3 more superior ones on each side; III. with 2 posterior and 2 anterior rows of 2–3 spines each; IV. with 1 distal and 1 stout basal spine below and an apical comb of setæ. *Tibia* I. with 6–7 spines in outer but only 2 in inner inferior row, besides 8–10 outer and 6 inner more superior spines; II. as in I., but with 3 spines in the inner inferior row; III. with several rows of spines; IV. with 1 inner (apical) and 2 outer (mesial and basal) spines below. *Patellæ* I.–III. with 2 (sometimes 1) inner and 1–2 outer spines; IV. unspined. *Femora* with the spines more numerous, but otherwise as in the ♀.

Pedipalps with the tibia incrassated. Palpal organ, seen from outer side, as in Pl. XI., fig. 27, the spine being curved in the middle and strong, except the short distal portion, which is bent almost at right angles and very slender and filiform.

Length ♀ 10, ♂ 7½ mm.

(**b**) 1 ♀ from Port Elizabeth (*J. L. Drège*, 1903), with black hairs on the anterior legs and the posterior row of eyes not procurved.

7. Ariadna capensis, n. sp.

1 ♀ (No. 5830) from Wynberg Hill (*F. Treleaven*, February, 1899).

Colour brownish-red, the head darker, especially anteriorly. Legs rufescent, the anterior ones redder, the first pair brownish-red, darkest on the tibia and metatarsus; anterior femora infuscated along middle below and on distal part of inner surface. Chelicera reddish-black. Abdomen purplish-black, with narrow yellow line on each side. Sternum reddish-brown. Labium dark brown, paler at apex. Coxæ reddish-yellow, scarcely at all infuscated.

Carapace a little shorter than the tibia and metatarsus of first leg;

width of head behind ocular area nearly $\frac{5}{6}$ of the length of first tibia. Posterior row of eyes slightly recurved, the medians together slightly wider than their distance from the posterior laterals.

Legs moderately hairy, resembling those of *bilineata*, except: *Metatarsus* II. sometimes with an inner upper spine at base; III. with 2 inferior and 1 anterior row of spines; IV. with a stout apical and basal inferior spine and 3–5 setæ in the apical comb. *Tibiæ* I. and II. with 6 spines in each inferior row, except the inner row of II., which has only 4 spines, the superior rows always of 3 spines; III. with 1 outer spine besides an inferior row of 3. *Femur* IV. spined above at base.

Chelicera with the lower tooth obsolete.

Length $9\frac{1}{4}$ mm.

8. Ariadna segestrioides, n. sp.

1 ♀ (No. 8396) from Dunbrody, Uitenhage Div. (*Rev. J. A. O'Neil*, 1898).

Resembling a *Segestria* in appearance.

Colour.—Carapace blackish-brown, slightly paler in the middle. Chelicera reddish-black. Legs blackish-brown to nearly black, the 2 posterior pairs paler distally, their tarsi, and, to a lesser extent, their metatarsi, pale yellowish, the 2 anterior pairs of tarsi reddish. Abdomen pallid, with a median series of purplish spots above, the under surface faintly suffused with purplish and with a dark purplish patch posteriorly before the spinners. Sternum and labium blackish-brown.

Carapace as long as the tibia and about $\frac{4}{5}$–$\frac{5}{6}$ of the metatarsus of first leg, its width just behind the eyes about $\frac{3}{4}$ of the length of the first tibia and much shorter than the metatarsus. Median eyes in close contact, their united width slightly exceeding their distance from the laterals, the posterior row recurved.

Legs.—Fourth femur not thicker than the first, its dorsal length more than 3 times its greatest thickness. Anterior tibia stout, nearly cylindrical, its width a little less than the space between the posterior lateral eyes. Short hairs on outer upper surface of the 3 anterior pairs of patellæ and tibiæ slightly thickened at base. Metatarsus I. considerably shorter than the tibia. Spines as in *bilineata*, n. sp., except: *Metatarsus* II. with 2 (sometimes 1) superior spines on each side, IV. with 4–5 setæ in the apical tuft and 4 stout spines below (including an apical pair); *tibia* I. with 3 inner and 3–4 outer superior spines, II. with 5–6 outer and 3 inner superior spines, III. with 2 rows of inferior spines, besides a row of

3 on posterior surface, IV. with 3 inferior spines; *femora* I.–III. with a couple of dorsal and generally 1–2 outer distal spines, I. also with 3, II.–III. with 1–2, and IV. with 1 inner distal spine.

Inferior tooth of *chelicera* indistinguishable.

Length $10\frac{3}{4}$, of carapace $4\frac{1}{4}$ mm.

9. Ariadna umtalica, n. sp.

Specimens.—(**a**) 1 ♀ (No. 12546) from Baviaanskop, 3 miles east of Umtali, Mashonaland (*D. L. Patrick*, June, 1902).

Colour.—Carapace dark brown, the ocular area black; chelicera reddish-black; abdomen pallid, suffused with purplish; legs infuscated as in dark specimens of *bilineata*, the 4 distal segments of the 2 posterior pairs, however, reddish-ochraceous above; the anterior tibia and metatarsus blackish-red; sternum and labium brown, the latter paler at apex.

Carapace as long as the tibia and $\frac{3}{4}$ of the metatarsus of first leg, much narrower in front, its width behind the ocular area about $\frac{2}{3}$ of the length of first tibia. Ocular area as in *bilineata*.

Legs.—Anterior legs, especially on the tibiæ, rather thickly clothed with longish, curved, black hairs, the first tibia stout, its width at least equal to the space between the posterior lateral eyes. Legs otherwise much as in *bilineata*, except: *Metatarsus* II. with an inner basal spine above the inferior row, III. with 2 anterior rows of 2–3 spines and a postero-inferior row of 4–6 spines, IV. with 5 stout spines (including an apical pair), the comb with about 8 setæ; *tibia* I. with 4 outer spines above the inferior row, III. with an anterior upper row of 2 and a posterior lower row of 3 spines, IV. with 0–1 inferior spines; *patella* I. with a short external spine; *femur* IV. with 1 inner distal and some dorsal spines.

Chelicera with minute distal tooth on lower margin.

Length 12, of carapace 5 mm.

(**b**) 1 ♀ from Kuruman, Bechuanaland (*G. E. Beare*). Length $15\frac{1}{4}$ mm. Larger than the type specimen, with darker abdomen and carapace, the latter as long as the tibia and $\frac{2}{3}$ of the metatarsus of first leg; otherwise apparently not differing from the type.

10. Ariadna scabripes, n. sp.

Specimens.—6 specimens, including several apparently adult ♀ ♀ (Nos. 9470, &c.), from Hanover (*S. C. Cronwright Schreiner*).

♀ ♀. *Colour.*—Carapace ochraceous, its lateral margins not blackened, the cephalic portion paler behind, brown at the sides

in front and blackened at the anterior margin, at least laterally. Chelicera brown or brownish-yellow, black at apex. Abdomen pallid, or the upper surface more or less suffused with dark purplish, the ventral surface with a pair of purplish patches posteriorly and sometimes one before the vulva. Legs almost uniformly pale yellowish, the anterior tarsi often darker than the other segments, which are without infuscated marks. Coxæ and sternum pale yellowish, the latter sometimes partly purplish; labium mostly infuscated at base, pale yellowish at apex.

Carapace subequal to or almost as long as the tibia and metatarsus of first leg, narrowed in front, its width just behind the ocular area about $\frac{4}{5}$ that of the tibia and subequal to that of the metatarsus of first leg. Median eyes in close contact, their distance from the posterior laterals generally less than (sometimes subequal to) their united width.

Legs rather short, stout, especially the fourth femur and first tibia, the former very distinctly thicker than the first femur, its dorsal length being only $2\frac{1}{2}$ times its greatest thickness, anterior tibia much stouter than the second pair and somewhat fusiform, its width being subequal to the space between the posterior pair of lateral eyes. Short hairs on the dorsal surface and upper part of lateral surface of patellæ and tibiæ of the 3 anterior pairs peculiar, being very numerous, curved, and suddenly swollen at the base, the long hairs on the segments normal, the naked strips on the dorsal surface narrower than usual, those on the patellæ being narrower than the setose strip between them. *Metatarsus* I. much shorter than the tibia, I. and II. with a single series of 7–8 (rarely 9) spines on each side, rarely with an additional superior spine on one of the legs; III. mostly with 2 anterior and 2 posterior rows of 1–3 spines each; IV. with 5 (sometimes only 4) stout spines below, including an apical pair, the apical tuft composed of 5–7 setæ. *Tibiæ* I. and II. with 5–10 spines in the lower rows (the inner row of second leg composed of only 3–4 spines), the upper row on each of 3–4 spines in I. and 0–3 in II., intermediate spines absent; III. with an infero-posterior row of 3–4 spines and occasionally with a posterior spine in addition, but without anterior spines; IV. with 0–2 inferior spines. *Patellæ* unspined. *Femur* I. with an internal and sometimes also a dorsal apical spine; II. unspined or with 1 internal and 1–2 dorsal spines; III. and IV. unspined.

Chelicera with 3 tiny teeth on superior border and a very minute, sometimes scarcely distinguishable, apical denticle on inferior border of inner margin.

Length of largest ♀ $9\frac{3}{4}$, of carapace 4 mm.

Synopsis of the South African species (♀ ♀) of *Ariadna* * :—

a. Chelicera with the apical tooth of inferior margin of inner surface well developed and as large as the 3 teeth of superior margin. Head very broad in front, its width behind the ocular area almost equalling the length of the first tibia. Metatarsi I. and II. with 2–3 rows of spines on each side. Cape Peninsula .. .. 1. *A. dentigera*, n. sp.

b. Chelicera with the inferior tooth minute or obsolete, smaller than the superior teeth. Head narrowed in front, its width about $\frac{3}{4}$–$\frac{4}{5}$ of the length of first tibia. Metatarsi I. and II. with only 1 row of spines on each side (sometimes with 1–2 superior spines in addition).

*a*¹. Metatarsus of first leg subequal to or longer than the tibia.

*a*². Tibia I. with 5–8 spines above the inferior row on each side. Anterior patella not spined. Caledon Div. .. .. .. 2. *A. lightfooti*, n. sp.

*b*². Tibia I. with 3–4 spines on each side above the inferior row. Anterior patella spined.

*a*³. Width of both median eyes together much greater than their distance from posterior lateral eyes. Bushmanland 3. *A. jubata*, n. sp.

*b*³. Width of both median eyes together not greater than their distance from posterior lateral eyes. Kentani District. 4. *A. kolbei*, n. sp.

*b*¹. Metatarsus of first leg distinctly shorter than the tibia.

*a*⁴. Legs short, the length of the first metatarsus being subequal to the width of the head just behind the eyes, and the fourth femur only about $2\frac{1}{2}$ times as long above as high. Colour yellow. Hanover. 10. *A. scabripes*, n. sp.

*b*⁴. Legs longer.

*a*⁵. Tibia I. with 5–6 superior spines on outer side. Patella I. spined internally. Hanover and Port Elizabeth .. 6. *A. karrooica*, n. sp.

*b*⁵. Tibia I. with only 3–4 superior spines on each side. Patella not spined internally.

*a*⁶. Patella I. not spined at all.

*a*⁷. Metatarsus IV. with 1–2 spines below. Tibia IV. unspined.

*a*⁸. Carapace as long as the tibia and $\frac{2}{3}$ of the metatarsus of first leg. Cape, Caledon, Stellenbosch, Paarl, and Malmesbury Divs. .. .. 5. *A. bilineata*, n. sp.

*b*⁸. Carapace only a little shorter than the tibia and metatarsus of first leg. Cape Peninsula. 7. *A. capensis*, n. sp.

*b*⁷. Metatarsus IV. with 4 stout spines below. Tibia IV. spined below. Uitenhage Div. .. .. 8. *A. segestrioides*, n. sp.

*b*⁶. Patella I. spined externally. Mashonaland and Bechuanaland. 9. *A. umtalica*, n. sp.

Gen. SEGESTRIELLA, n. gen.

Allied to *Ariadna*, Aud., but differing in having the body elongate cylindrical, the abdomen obtusely produced beyond the spinners, and the fourth pair of legs very short, not reaching hind end of abdomen when stretched out and with the femur very short and stout, strongly

* Simon mentions the occurrence of the genus in South Africa, but does not appear to have described any of the species.

swollen dorsally, the width of the femur between dorsal and ventral edges about ½ its dorsal length and almost twice the width of the first femur.

SEGESTRIELLA GRYLLOTALPA, n. sp.

1 ♀ (No. 11698) from Stompneus, St. Helena Bay, Malmesbury Div. (*J. E. C. Goold*, 1902).

Colour.—Carapace brownish red, yellowish at the sides posteriorly and at hind margin, with some radiating infuscate marks, the head dark reddish-brown to nearly black. Chelicera black. Abdomen pale yellowish, with the following purplish-black markings : A band crossing anterior end above the pedicle and extending backwards down each side to middle of abdomen ; a median, moniliform, dorsal band, narrow in front but broad behind, extending along whole length ; a pair of large ventral marks in front of the spinners, each sending a faint stripe anteriorly to the posterior spiracles, which are joined by a transverse band. Legs pale ochraceous, the second pair infuscated on dorsal surface of femur, apex of tibia, basal half and apex of metatarsus and distal half of tarsus ; the first pair darker, with brown tibia, infuscated as in the second pair. Coxæ pale yellowish. Sternum yellow, partly blackened. Labium dark brown at base, paler distally.

Carapace as long as the tibia, metatarsus and ¾ of the tarsus of first leg, with sinuous lateral margins, narrowed in front and slightly constricted behind the narrowed part, of which the width is distinctly less than the length of the first tibia. Ocular area with slightly recurved hind margin, the width of the 2 median eyes slightly exceeding their distance from the posterior lateral eyes.

Legs with black hairs, the first tibia stout, its width equal to the space between the posterior lateral eyes. *Metatarsus* I. as long as the tibia ; I. and II. with 7–9 spines in each inferior row ; III. with 1 inner superior spine and 1 inner and 3 outer inferior spines ; IV. with 1 apical spine below and 3–4 setæ in the comb. *Tibiæ* I.–II. with 5–8 spines in each inferior row ; I. also with 3 outer and 4 inner, and II. with 0 outer and 3 inner more superior spines ; III. with 2 outer inferior spines ; IV. unspined. *Patellæ* unspined. *Femur* I. with 2–3, II. with 2, and III. with 0–1 dorsal spines ; I.–III. also with 1 internal distal spine ; IV. unspined.

Chelicera with 3 small superior teeth and 1 minute apical inferior denticle.

Length 10¼, of carapace 3¾, of abdomen 6 mm. ; width of carapace 2, of abdomen 2¼ mm.

Family CAPONIIDÆ.

Gen. CAPONIA, E. Sim.

1. Caponia spiralifera, n. sp.

Specimens.—20 ♂ ♂ and 28 ♀ ♀ and young (No. 9469, &c.) from Hanover (*S. C. Cronwright Schreiner*).

♂ ♂ ♀ ♀. *Colour.*—Carapace and limbs deep yellow or somewhat orange-yellow. Sternum yellow, with large, roundish-cordate, orange, central area, which is more distinctly defined in the ♂ ♂ than in the ♀ ♀; abdomen pale yellow, often with ventral blackish mark posteriorly in the ♀ ♀; the claws, the area containing the median eyes, and the base of each lateral eye black, the margins of the sternum with a black or dark brown spot at base of each leg or at least of each of the 3 posterior pairs.

Carapace as long as the tibia, metatarsus, and $\frac{1}{2}$–$\frac{3}{4}$ of the tarsus of first leg. Anterior lateral eyes a little larger than the posterior lateral eyes, the middle lateral eyes variable, equal to (rarely slightly smaller than) the posterior eyes or intermediate in size between the anterior and posterior pair (very rarely subequal to the anterior pair).

Palpal organ of ♂.—Process of bulb curved somewhat spirally, the outwardly directed basal part rather longish, scarcely thickened at the end, which is obtuse and rounded (Pl. XI., fig. 29); the middle portion clavate distally and curving outwards and bearing a small, simply recurved, inner, distal spine, and sometimes a tiny process next to it; the distal portion strong, recurved, bifid at apex, the main branch short, compressed, obliquely lanceolate and pointed (Pl. XI., fig. 28), the inferior branch longer, slender, filiform and subterete, the apices of the 2 branches diverging.

Length of ♂ ♂ 7–9, of ♀ ♀ up to $12\frac{1}{4}$ mm.

2. Caponia karrooica, n. sp.

Specimens.—4 ♂ ♂ and 3 ♀ ♀ (No. 12876) collected at Matjesfontein, Worcester Div., by Mr. R. M. Lightfoot, my wife, and myself.

Very close to *C. spiralifera*, n. sp., but differing slightly in the structure of the palpal organ of the ♂.

Carapace and *colour* as in *spiralifera*, but the abdomen without posterior black patch below.

Process of palpal organ with the outwardly directed basal part

short, nearly or quite rectangular at the bend (except in one specimen, where it is almost as in *spiralifera*); the middle part with its clavate apex not or scarcely curving outwards and bearing a compressed, strongly sigmoid, inner distal spine; the distal incurved part with shorter apical fork, of which the longer inferior branch is distinctly compressed and laminate and about as broad as the evenly pointed shorter main branch (Pl. XI., fig. 30).

Length ♂ ♂ $6\frac{1}{4}$–$7\frac{1}{4}$ mm., ♀ up to 9 mm.

3. Caponia forficifera, n. sp.

Specimens.—(**a**) 2 ♂ ♂ (No. 7815) from Brandvlei, Worcester Div. (*I. Meiring, W. F. P.*, August, 1900).

Colour as in the foregoing species, but the carapace and, to a lesser extent, the limbs more orange; abdomen without posterior black patch.

Carapace very slightly or very distinctly longer than the tibia, metatarsus, and tarsus of first leg. Eyes as in the foregoing species.

Process of pedipalp with the basal part short, scarcely or not at all thickened at the bend, which is obtuse and rounded; clavate end of middle part not curving outwards and bearing a lightly curved inner spine, which runs close to the inturned distal part; the latter with the fork very short, scissors-shaped, both blades compressed and subsimilar or the inferior branch slightly longer and narrower than the main branch (Pl. XI., fig. 31).

Length 7 mm.

(**b**) 1 ♂ from the Pass at Avontuur near Stormsvlei, Swellendam Div. (*W. F. P.*).

(**c**) 1 ♂ from the forest at Knysna (*W. F. P.*, March, 1896). Colour yellow (evidently that of a recently moulted specimen).

4. Caponia braunsi, n. sp.

1 ♂ (No. 12905) from Willowmore (*Dr. H. Brauns*).

Closely allied to the preceding species but larger.

Carapace dark orange, the central part paler yellowish; its length equal to that of the tibia, metatarsus, and about $\frac{3}{4}$ of the tarsus of first leg.

Process of pedipalp with the basal bend thickened and angular but the apical fork small and nearly as in *forficifera*, n. sp.; the inferior branch slenderer than the main branch (Pl. XI., fig. 32).

Length $10\frac{3}{4}$ mm.

5. Caponia capensis, n. sp.

Specimens.—(**a**) 1 ♂ (No. 12835) from the slopes of Devil's Peak (*W. F. P.*, September, 1903) and several ♀ ♀, all from the Cape Peninsula.

♂. Closely allied to *forficifera*, n. sp., but differing slightly in the form of the palpal organ, the process of which has the basal part thickened at the bend to form a prominent angle, the fork of the distal part larger, both branches compressed and strongly acuminate at the apex, and the inferior branch a little longer than the main branch (Pl. XI., fig. 33).

Carapace and *colour* as in *forficifera*.

Length 8 mm.

(**b**) 2 ♂ ♂ and several ♀ ♀ from Stompneus, St. Helena Bay, Malmesbury Div. (*J. E. C. Goold*).

6. Caponia hastifera, n. sp.

Specimens.—(**a**) 2 ♂ ♂ (No. 12847) from Willowmore (*Dr. H. Brauns*, 1903).

Carapace orange-yellow, paler in the middle, its length slightly or distinctly exceeding that of the tibia, metatarsus, and tarsus of first leg.

Process of pedipalp with the basal part short, more or less angular at the bend; the inner spine at distal end of middle part strong, acuminate, curved near base; the main branch of apical fork laminate, pointed and curving towards the inferior branch, which is longer, filiform, and much slenderer (Pl. XI., fig. 34).

Length $7\frac{1}{2}$ mm.

(**b**) 1 ♂ and 1 ♀ from Dunbrody, Uitenhage Div. (*Rev. J. A. O'Neil*, 1899).

7. Caponia simoni, n. sp.

1 ♂ and 1 ♀ (No. 3310) from Worcester (*W. F. P.*, September, 1896).

♂. *Carapace* orange, its length a little less than that of the tibia, metatarsus, and tarsus of first leg; eyes as in all the foregoing species.

Process of pedipalp with the basal part longish and strongly produced at the bend; the inner spine at distal end of the middle part short, recurved, and rod-like, with rather obtuse (not acuminate) apex; the distal part with the inferior branch of the apical fork laminate, broader than the main branch and itself bifid (Pl. XI., fig. 35).

Length $5\frac{3}{4}$ mm.

Synopsis of the species of *Caponia* (♂ ♂) described above * :—

a. Process of pedipalp bifid at apex, the branches entire.
  a^1. Inturned distal part of process strongly recurved in the direction of the clavate middle part (figs. 29–30). Carapace shorter than the tibia, metatarsus, and tarsus of first leg.
    a^2. Inner spine at distal end of the clavate middle part of process simply recurved; basal part of process longish, obtuse at the bend (fig. 29). Hanover .. .. 1. *C. spiralifera*, n. sp.
    b^2. Inner spine of middle part of process sigmoid; basal part of process short, more angular at the bend (fig. 30). Matjesfontein.
2. *C. karrooica*, n. sp.
  b^1. Inturned distal part of process not recurved in the direction of the clavate middle part (as in figs. 31–34).
    a^3. Apical fork of process small (figs. 31 and 32).
      a^4. Branches of fork more or less subsimilar; basal bend of process obtuse and rounded (fig. 31). Carapace at least as long as the tibia, metatarsus, and tarsus of first leg. Worcester, Swellendam, and Knysna Divs. .. .. 3. *C. forficifera*, n. sp.
      b^4. Inferior branch of fork much slenderer than the main one; basal bend of process angular (fig. 32). Carapace shorter than the tibia, metatarsus, and tarsus of first leg. Willowmore.
4. *C. braunsi*, n. sp.
    b^3. Apical fork of process larger (figs. 33 and 34). Carapace at least as long as the tibia, metatarsus, and tarsus of first leg.
      a^5. Branches of fork compressed, nearly equally wide, not converging; basal bend of process strongly angular (fig. 33). Cape and Malmesbury Divs. .. .. 5. *C. capensis*, n. sp.
      b^5. Inferior branch of fork subulate and much slenderer than the laminate main branch, which converges towards it; basal bend of process less angular at the bend (fig. 34). Willowmore and Uitenhage Divs.
6. *C. hastifera*, n. sp.
b. Process of pedipalp bifid at apex, the inferior branch being also bifid; basal part of process strongly produced outwards at the bend (fig. 35). Worcester.
7. *C. simoni*, n. sp.

Gen. DIPLOGLENA, n. gen.

Closely allied to *Caponia* but with the carapace (Pl. XI., fig. 37) much more broadly obtuse in front and with only 2 eyes (corresponding to the median pair and about half a diameter apart); the clypeus many times as long as an eye's diameter and strongly convex, being vertical in front but nearly horizontal behind. Sternum with a short marginal process on each side between the coxæ of the first leg and pedipalp (Pl. XI., fig. 38). Coxæ of pedipalps much

* *C. secunda*, Pocock (Ann. Mag. N. H., ser. 7, vol. vi., p. 321, 1900), from Grahamstown, and *C. natalensis* (O. P. Cambridge) (*Ibid.*, ser. 4, vol. xiv., p. 170, 1874), from Natal are the only other species described. The ♀ ♀ appear indistinguishable from one another, and *C. secunda* may be identical with any of the species described here. The species figured by E. Simon (Hist. nat. Araign., 2 éd., p. 326, fig. 293) is not identical with *natalensis*.

broader than in *Caponia* but the labium similar. Legs similar in both sexes and resembling those of *Caponia*, except that the first pair, especially their tibia and femur, are much stouter than the second pair.

Male with the patella of pedipalps longer than broad, its under side at least as long as that of the tibia; tibia constricted at base, expanding funnel-shaped distally, its upper side longer than in *Caponia*, being as long as its under side; tarsus reniform, but smaller than in *Caponia;* palpal organ quite different, the bulb having a pair of short spinous processes instead of a very long one.

Diploglena capensis, n. sp.

Specimens.—(**a**) 3 ♂ ♂, 4 ♀ ♀, and 2 young (No. 11687, &c.) from St. Helena Bay, Malmesbury Div. (*J. E. C. Goold,* ♂ ♂ in May and June, 1902).

♂ ♂ ♀ ♀. *Colour.*—Carapace orange-red or orange-yellow; legs yellow; abdomen very pale yellowish; sternum orange, with dark marginal spots.

Carapace as long as the tibia, metatarsus, and $\frac{1}{2}$–$\frac{2}{3}$ of the tarsus of first leg.

Bulb of *palpal organ* bearing at its apex 2 short spinous processes, of which one (usually situated posteriorly and curved inwards) is thick and bears a thin rounded lobe under the truncated apex, while the other (usually situated anteriorly and curved outwards) is strongly flattened and runs from a conically inflated base (Pl. XI., fig. 36).

Length ♂ $6\frac{1}{4}$, ♀ $7\frac{1}{4}$ mm.

Also ♀ ♀ of apparently the same species from:—

(**b**) Malmesbury (*W. F. P.*, 1897).

(**c**) Cape Peninsula (*W. F. P.*, 1896).

Family PRODIDOMIDÆ.

Gen. PRODIDOMUS, Hentz.

1. Prodidomus capensis, n. sp.

Specimens.—(**a**) 1 ♀ (No. 717) from Cape Town (*W. F. P.*, August, 1896).

Colour rufescent, the legs paler and more yellowish than the carapace; the abdomen very pale yellowish, the upper surface tinged with purple, especially posteriorly.

Carapace with the front margin obtuse and evenly rounded; hairs

rubbed off; ocular area much wider than long, the space between the 2 posterior eyes slightly exceeding the length of an eye.

Chelicera large, strongly diverging and nearly vertical, their anterior basal angles prominent.

Legs hairy or setose below, at least distally; fourth trochanter as long as the coxa; two posterior pairs of tibiæ and metatarsi with 1–2 slender apical spines.

Coxæ of pedipalps with the process long and slender.

Vulva consisting of a pair of oval cavities, which converge posteriorly and are bordered on the median and posterior sides by a curved brown ridge; the median line grooved (Pl. XI., fig. 39).

Length of trunk 6·8 mm.

(**b**) 1 ♀ from Clanwilliam (*Mrs. W. N. C. Marchant*) and 1 ♀ from near Rondegat, near Clanwilliam (*C. L. Leipoldt*). Abdomen sometimes entirely pale yellow. Anterior edge of carapace with numerous fine long hairs.

(**c**) 1 ♀ from Dunbrody, Uitenhage Div. (*Rev. J. A. O'Neil*).

2. Prodidomus purpurascens, n. sp.

1 ♀ (No. 3211) from the northern slopes of Devil's Peak (*F. Treleaven*, November, 1897).

Colour as in *capensis*, but the abdomen darker purple above and the carapace darkened at the edges; the hairs on under side of abdomen fulvous.

Carapace with fine short hairs; the anterior margin with fine long setæ, the middle portion before the eyes convexly produced; ocular area only a little wider than long, the space between the 2 posterior eyes slightly less than the length of the eyes.

Chelicera of moderate size, directed downwards and forwards and only moderately diverging, their outer margins only slightly further apart distally than at base, their width together considerably less than that of widest part of carapace.

Legs hairy; fourth trochanter as long as the coxa; two posterior pairs of tibiæ and metatarsi with 1–2 fine apical spines, the fourth tibia also with a mesial spine below.

Coxæ of pedipalps with the process stout and rather short.

Vulva a transverse plate, brown on each side and pallid along the middle, with a pair of dark spots at hind margin; the surface with a broad shallow depression bordered posteriorly by the raised hind margin, which forms a transverse ridge in middle portion; each end of the ridge with a small cavity in front of it (Pl. XI., fig. 40).

Length of trunk 4·8 mm.

3. Prodidomus scaber, n. sp.

A ♀ and ♂ (No. 3916) from Prince Albert (*W. F. P.*, September, 1896).

♀ (*Type*). Pale yellowish, pubescent, the carapace with a fringe of long fine setæ on anterior margin.

Anterior margin of *carapace* evenly rounded in front, obtuse.

Ocular area, *chelicera*, and *coxæ of pedipalps* as in *P. purpurascens*, n. sp.

Legs.—Fourth trochanter subequal to (or a trifle shorter than) the coxa ; tibiæ of posterior legs with slender basal, mesial, and apical spines below, the posterior metatarsi with mesial and apical spines.

Vulva forming a broad, flat, brown plate, presenting in spirits the appearance of Pl. XI., fig. 41, and provided at its hind margin with a pair of twin tubercles, in front of which are a pair of tiny holes.

♂. Carapace and limbs rufescent. Upper surface of body and especially the limbs scabrous, with short, stout, rod-like hairs or spinules, the lower surface with finer hairs.

Posterior *legs* without mesial or basal spines on the segments.

Pedipalps.—Tibia appearing triangular from above, the outer distal angle produced and deeply bifid at apex. Palpal organ sharply aculeate at apex (Pl. XI., fig. 42).

Length of trunk ♀ $2\frac{3}{4}$, ♂ 3 mm.

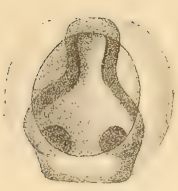
EXPLANATION OF PLATES X. AND XI.

Plate X.

FIG.		
1.	*Auximus schreineri*, n. sp.	Vulva.
2.	,, *silvaticus*, n. sp.	,,
3.	,, *longipes*, n. sp.	,,
4.	*Pseudauximus pallidus*, n. sp...	,,
5.	*Stegodyphus canus*, n. sp.....	,,
6.	,, *tentoriicola*, n. sp.	,,
7.	*Adonea variegata*, n. sp.	,,
8.	*Seothyra fasciata*, n. sp.	,,
9.	*Dresserus angusticeps*, n. sp. ..	,,
10.	,, *laticeps*, n. sp.	,,
11.	*Scytodes montana*, n. sp.	,,
12.	,, *lycosella*, n. sp.	,,
13.	,, *triangulifera*, n. sp. ..	,,
14.	,, *flagellata*, n. sp.....	,,
15.	,, ,, ,, ...	Left palp of ♂ from outer side.
16.	,, *testudo*, n. sp.....	Vulva.
17.	,, ,, ,, ...	Left palpal organ of ♂ from outer side.
18.	,, *gooldi*, n. sp.	Vulva.
19.	,, *karrooica*, n. sp.....	,,
20.	,, *caffra*, n. sp.	,,
21.	,, *cedri*, n. sp.....	,,
22.	,, *lanceolata*, n. sp.	Left palp of ♂; *a*, from side; *b*, from front.
23.	,, *elizabethæ*, n. sp.	Left palp of ♂ seen partly from outer side and partly from front.

Plate XI.

24.	*Drymusa silvicola*, n. sp.	Under side of abdomen of ♀.
25.	,, ,, ,, ...	Left palp of ♂ from upper side.
26.	,, *producta*, n. sp.....	Epigastric area of ♀.
27.	*Ariadna karrooica*, n. sp.....	Left palp of ♂ from outer side.
28.	*Caponia spiralifera*, n. sp.	Palpal organ and tarsus of right pedipalp of ♂ from front.
29.	,, ,, ,, ...	Right palpal organ of ♂ from below.
30.	,, *karrooica*, n. sp.....	,, ,, ,,
31.	,, *forficifera*, n. sp.	,, ,, ,,
32.	,, *braunsi*, n. sp.....	,, ,, ,,
33.	,, *capensis*, n. sp.	,, ,, ,,
34.	,, *hastifera*, n. sp.	,, ,, ,,
35.	,, *simoni*, n. sp.	,, ,, ,,
36.	*Diploglena capensis*, n. sp.	,, ,, ,,
37.	,, ,, ,, ...	Carapace.
38.	,, ,, ,, ...	Anterior part of sternum and mouth parts.
39.	*Prodidomus capensis*, n. sp.	Vulva.
40.	,, *purpurascens*, n. sp.	,,
41.	,, *scaber*, n. sp.....	,,
42.	,, ,, ,, ...	Distal part of right pedipalp of ♂ from outer side.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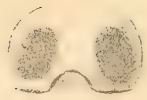
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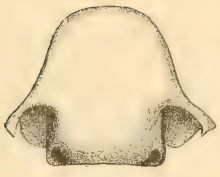
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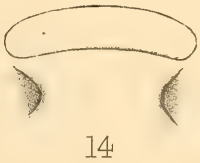
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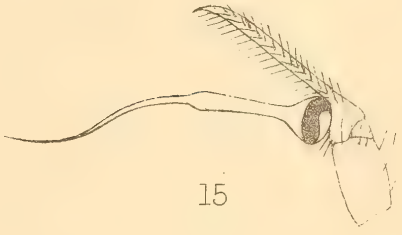
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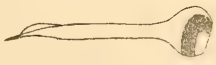
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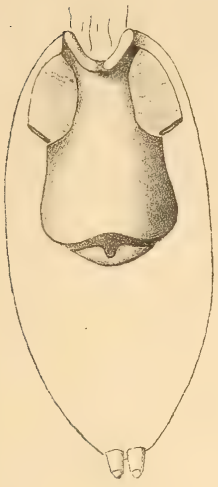

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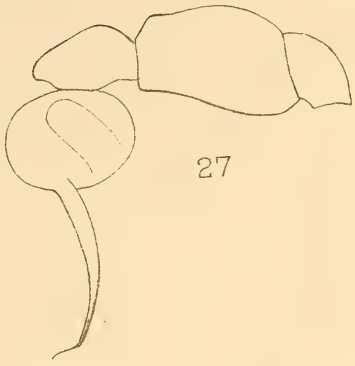

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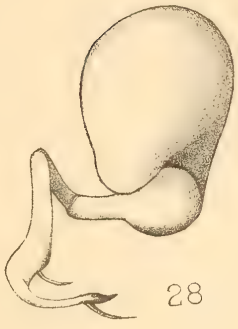

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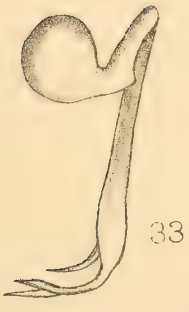

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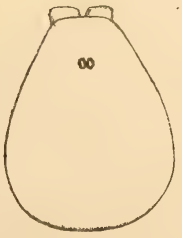

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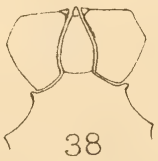

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West, Newman lith. London.

W. F. Purcell del.

SOUTH AFRICAN VERBENACEÆ.

By H. H. W. Pearson, M.A., F.L.S., South African College, Cape Town.

(Read September 28, 1904.)

The account of the South African Verbenaceæ contained in the *Flora Capensis* (vol. v., pp. 180 *et sqq.*) was based upon materials preserved in the principal British Herbaria, supplemented by specimens lent from other European collections. Among the South African material kindly placed at my disposal by Dr. Bolus, Dr. MacOwan, Dr. Kolbe, Dr. Schönland, and Mr. Medley Wood I have found certain new species, as well as good specimens of hitherto imperfectly known species, of which detailed descriptions are given below. *Bouchea incisa* and *Clerodendron reflexum* are at present only recorded from Tropical Africa.

Gen. LIPPIA, Linn.

Lippia pedunculata, sp. n.

Fruticulus rectus ramis subteretis, striatis, hispido-scabridis. *Folia* opposita, brevissime petiolata, ovata vel elliptico-ovata, basim attenuata, apice obtusa vel sub-acuta, crenato-serrata, rugosa, supra hispidulo-scabrida, infra in nervis hispido-scabrida, profuse glandulifera. *Spicæ* tum globosæ, denique cylindricæ, axillares, solitares geminatæve, pedunculis longis tenuibus hispidis suffultæ. *Bracteæ* oblongæ, basim truncatæ, apice subito acuminatæ vel caudato-acuminatæ, utrinque præsertim marginibus hispidæ, flores haud superantes. *Calyx* perspicue 2-lobatus, 4-nervatus, extus dense molliterque villosus, intus glaber; lobi vix tubo æquantes, 2-nervati, plus minusve perplexe 2-dentati. *Corolla* extus supra medium villosa, intus in faucibus puberula.

Kalahari Region: Transvaal; without precise locality, *J. H. McLea* in *Herb. Bolus.*

A woody perennial with erect, subterete, striate, hispido-scabrid branches. *Leaves* opposite, very shortly petioled, ovate or elliptic-ovate, narrowed at the base, obtuse or subacute, rugose, crenate-serrate, roughly hispidulous above, hispid on the nerves beneath, gland-dotted, 3–5 cm. long, 1–1·5 cm. broad; petiole 2 mm. long. *Bracts* broadly oblong, abruptly acuminate or caudate-acuminate, truncate at the base, hispid on both surfaces and especially along the margins, not exceeding the flowers, 3–4·5 mm. long, 2–2·5 mm. broad. *Calyx* conspicuously 2-lobed, 4-nerved, softly villous without, 1·5–2 mm. long; lobes almost as long as the tube, 2-nerved, more or less obscurely 2-toothed. *Corolla* villous above the middle externally, puberulous in the throat, 4–5 mm. long.

L. pedunculata has affinities both with *L. scaberrima* and *L. asperifolia*, being apparently more closely allied with the former. The most marked characters which separate it from *L. scaberrima* are found in the 4-toothed calyx, the smaller bracts, the more pronounced hairiness, and the comparatively smoother surface of the whole plant. From *L. asperifolia* it differs in the 4-toothed calyx, the larger bracts and spikes, and the less hairy, rougher, and larger leaves.

Gen. BOUCHEA, Cham.

The following descriptions of three * new species of *Bouchea* and an amended description of *B. glandulifera* invalidate the key to the section *Chascanum* † to which all these species belong. For the convenience of students using the *Flora Capensis*, a revised key for that part of the genus is here given.‡

Section 2. Chascanum. Ripe fruit not separating spontaneously into cocci; areole basal or on the anterior face; flowers bracteolate.

Areole basal:
Leaves toothed .....(6) **cuneifolia.**
Leaves entire .....(7) **latifolia.**

* *B. incisa* is at present known only from a locality within the tropics. It is, however, included here, as it may confidently be expected to occur in extra-tropical Transvaal.

† *Flora Capensis*, vol. v., 198, 199.

‡ The old species are numbered as in *Flora Capensis.*

Areole anterior :
  Flowering calyx-tube not exceeding 1 cm. :
    Fruiting spike exceeding 10 cm. :
      Bracts and calyx-tube puberulous but without capitate glands ..... (8) **garepensis.**
      Bracts and calyx-tube with capitate glands, otherwise glabrous ..... (10) **glandulifera.**
    Fruiting spike not exceeding 7 cm. :
      Leaves crowded :
        Leaves sessile, whorled (rarely opposite) ..... (9) **cernua.**
        Leaves petioled, opposite ..... **cæspitosa.**
      Leaves distant, opposite :
        Nearly all leaves entire ..... **integrifolia.**
        Leaves deeply serrate ..... **cæspitosa.**
        Leaves deeply pinnati-partite with linear segments ..... (13) **pinnatifida.**
  Flowering calyx-tube exceeding 1 cm. :
    Leaves cuneate or oblong-cuneate, entire except at the rounded apex ..... (11) **namaquana.**
    Leaves ovate-oblong with distantly toothed margins, less than 3 cm. long ..... (12) **pumila.**
    Leaves pinnatifid or incised, 6–7 cm. long ..... **incisa.**

Bouchea glandulifera, H. H. W. Pearson in Thiselton-Dyer *Flora Capensis*, v. 204.

[This species was originally described from an immature specimen (*Schlechter* 76). The following amended description is based upon perfect specimens in the herbaria of Dr. Bolus and Dr. Schönland.]

Descriptio emendata : Fruticulus glaberrimus, ramosus laxe. *Folia* opposita, petiolata, oblonga subrhomboideave, obtusa, marginibus obtuse incisis, nervis lateralibus obscuris. *Racemus* terminalis, simplex, spicoideus, confertus, bracteatus. *Bracteæ* anguste lineares, acutæ, marginibus membranaceis, glandulis minutis capitatis pedicellatis instructis ; bracteolæ setulosæ, glabræ. Flores pedicellis tenuibus suffulti. *Calycis* tubus rectus, prominente striatus, glandulis capitatis instructus, cæterum glaberrimus ; dentes parvi, acuti, glanduliferi. *Corollæ* tubus arcuatus, extus glaber, intus præsertim in faucibus hispido-villosus. *Antheræ* filamentis glanduliferis suffultæ. *Fructus* maturus nigricans ex coccis cohærentibus 2 constatus, oblongus, basim latior, posteriore paullo arcuatus, anteriore areola lata instructus.

Kalahari Region : Little Bushmanland ; Stickland, *Schlechter* 76.
Western Region : Little Namaqualand ; I'us, 2,800 ft., *Schlechter* 11,410.

A loosely branched glabrous shrub, 30–60 cm. high ; internodes 4–6 cm. long. *Leaves* opposite, oblong or subrhomboid, obtuse, with

obtusely incised margins, glabrous, 1·5–5·5 cm. long, 0·5–2·5 cm. broad; petiole slender, 0·75–2 cm. long. *Raceme* spicoid, up to 25 cm. long (in fruit). *Bracts* linear, acute, with membranous margins, beset with minute stalked capitate glands, 4–5 mm. long; bracteoles reduced to bristles, glabrous, 1 mm. long. *Pedicels* of the flowers 1–2 mm. long. *Calyx-tube* straight, ridged, beset with minute glands, otherwise glabrous, 8–10 mm. long; teeth small. *Corolla-tube* curved, glabrous on the outside, hispid-villous within especially in the throat, 2 cm. long. *Fruit* black when ripe, of 2 cohering cocci, broader at the base than above, curved on the posterior face, with a broad anterior areole, 2–3 mm. long, 2 mm. broad at the base.

B. glandulifera is closely related to *B. garepensis*, from which, however, it appears to be sufficiently distinct in its lobed leaves and gland-beset bracts and calyces.

Bouchea cæspitosa, sp. n.

Planta parva, lignosa, cæspitosa, pubescentia hispidulosa densa reflexa vestita. *Radix* lignosa, recta, altissima. *Folia* opposita, conferta, petiolata, triangulari-ovata, obtuse 7–9-serrata -pinnatifidave, basim attenuata, apice obtusa, subcoriacea, nervis lateralibus principiis obscuris 6–8 utrinque, dense hispidula. *Spica* terminalis, conferta, pauciflora. *Bracteæ* lineares, obtusæ hispidulæ; bracteolæ setulosæ, hispidulæ. *Flores* sessiles. *Calycis* tubus (in fructu) gibbosus, minute subæqualiterque 5-dentatus, extus hispidulus, intus glaber. *Fructus* ex coccis cohærentibus 2 constatus, oblongus, posteriore paullo arcuatus, anteriore areola excavata instructus.

Western Region: Lesser Namaqualand; I'us, 2,800 ft. *Schlechter* 11425, *in Herb. Bolus.*

A small deeply rooted tufted perennial about 4 cm. high, hispidulous with reflexed hairs. *Leaves* opposite, crowded, triangular-ovate, 7–9-serrate or -pinnatifid, with obtuse lobes and apex, densely hispidulous, 2·5–3 cm. long, about 1·5 cm. broad; petiole ·75–1·25 cm. long. *Spike* terminal, crowded, few-flowered, 1 cm. long. *Bracts* 3–4 mm. long; bracteoles 2 mm. long. *Flowers* sessile. *Calyx-tube* gibbous in fruit, minutely 5-toothed, hispidulous without, glabrous within, 7–9 mm. long. *Corolla* not seen. *Fruit* of 2 cohering cocci, oblong, somewhat curved on the posterior face, with an anterior areole, 4–5 mm. long.

B. cæspitosa is a distinct species widely separated by its short calyx and small fruit from *B. pumila*, to which it bears a superficial resemblance. It should probably be placed near *B. pinnatifida*, from which it is at once distinguished by its leaf-characters.

In view of the very dry region in which Schlechter's specimen was gathered, the cæspitose habit is possibly not to be regarded as a character of specific value.

Bouchea integrifolia, sp. n.

Fruticulus basi paullo ramosus, ramis quadrangularibus parce hispidulis. *Folia* opposita, sessilia, simplicia, integra vel rarius versus apicem irregulariter 1–2 acute serrata, lineari-oblonga, basim plus minusve attenuata, apice acuta vix echinata, subcoriacea, marginibus crassis, perspicue 1-nervata, glabra vel parcissime hispidula, profuse glandulis instructa. *Racemus* spicoideus, divaricatus, confertus, terminalis vel axillaris, glabrescens vel parce hispidulus. *Bracteæ* lineari-lanceolatæ, acutæ, marginibus hispidis; bracteolæ 2, subulatæ, acutæ, marginibus parcissime hispidis. *Flores* pedicellis suffulti. *Calyx* 5-angularis, subæqualiter breviterque 5-dentatus, extus glaber, intus pubescens. *Corollæ* tubus arcuatus, extus glaber, intus faucibus hispidulus; lobi oblonga, apicibus late rotundati emarginative. *Antheræ* late triangulares, basim paullo lobatæ, filamentis glabris suffultæ. *Fructus* oblongus, ex coccis cohærentibus 2 constatus, posteriore arcte arcuatus, areola excavata anteriore instructus.

Coast Region: Knysna, *Newdigate* 86, *in Herb. MacOwan.*

A shrub, 25–30 cm. high, with angular sparsely hispid stems; internodes 1·5–2 cm. long. *Leaves* opposite, sessile, simple, entire or rarely with 1–2 acute serrations near the apex, linear-oblong, narrowed in the upper third to a hard acute apex, glabrous or with a very few coarse hairs, profusely glandular on both surfaces, 2·5–3 cm. long, 3–4 mm. broad. *Raceme* spicate, 3–6 cm. long. *Bracts* 6–8 cm. long; bracteoles 2–4 mm. long. *Pedicels* 2–4 mm. long. *Calyx-tube* 5-angular, glabrous without, pubescent within, 7–9 mm. long. *Corolla-tube* curved, 10–12 mm. long. *Fruit* of 2 coherent cocci, with an anterior areole, strongly curved, 4 mm. long.

B. integrifolia appears to be most nearly related to *B. cernua*, from which it is easily distinguished by its opposite, entire, acute leaves.

Bouchea incisa, sp. n.

Fruticulus ramis quadrangularis hispidis pilis reflexis. *Folia* opposita, petiolata, simplicia, late oblonga, obtuse 7–9 pinnatifida vel vix pinnatipartita, basim attenuata petiolis decurrentia, apice obtusa vel subacuta, subcoriacea, marginibus hispido-ciliatis, nervis lateralibus principiis utrinque 6–8, minute hispidula, glandulosa; petiolus latus, supra canaliculatus. *Spica* simplex, axillaris, pauciflora, conferta, hispidula. *Bracteæ* subulatæ, hispidulæ, bracteolæ bracteis similes. *Flores* sessiles. *Calycis* tubus 5-angularis, subæqualiter 5-dentatus, extus hispidulus, intus puberulus; dentes subulati, acuti, hispiduli. *Corollæ* tubus rectus, extus glaber, glandulosus, intus villosus. *Staminum* filamentæ hispidulæ. *Fructus* oblongus, rectus, ex coccis cohærentibus 2 constatus, areola excavata anteriore instructus.

Tropical Africa: Northern Transvaal; Sand River, 2,500 ft., *R. Schlechter* 4594, *in Herb. Bolus.*

A low shrub with stout angular stems hispid with reflexed hairs; internodes 1–4 cm. long. *Leaves* opposite, petioled, broadly oblong, incised (the 6–8 lateral lobes extending about half-way to the midrib), minutely hispidulous, ciliate along the margins, with an obtuse or sub-acute apex, 6–7 cm. long, 3–4 cm. broad; petiole 1·5–2 cm. long. *Spike* unbranched, axillary, few-flowered, 3–4 cm. long. *Bracts* subulate, 5–6 mm. long; bracteoles 2 mm. long. *Flowers* sessile, crowded. *Calyx-tube* hispidulous without, puberulous within, 1·5 cm. long; teeth subulate, 1–1·5 mm. long. *Corolla-tube* straight, villous within, 2–2·2 cm. long. *Fruit* oblong, straight, of 2 cohering cocci, with an anterior areole, 7 mm. long.

B. incisa is related to *B. pumila*, from which it conspicuously differs in the large pinnatifid leaves.

Gen. VERBENA, Linn.

Verbena pulchella, *Sweet, Brit. Flow. Gard.*, ser. 1, vol. iii., t. 295.

A small much-branched shrub with ascending branches. *Leaves* decurrent on the short petiole, pinnatifid-laciniate with linear, somewhat acute, entire lobes, hirsute with adpressed scattered stiff hairs. *Spike* pedunculate, terminal, usually solitary, sub-canescent; bracts lanceolate, acuminate. *Calyx* roughly pubescent, bearing at the angles shortly stalked disc-shaped glands, about 5 mm. long. *Corolla* violet, twice as long as the calyx-tube,

bearded within at the insertions of the anthers, otherwise glabrous. *Anthers* with scarcely exserted recurved, hooked appendages. *DC. Prodr.* xi. 552 (*sub V. tenera, Spreng.*).

Eastern Region: Natal; Edendale, 2,500 ft. *T. R. Sim ex Herb. Natal.*

This species, for the determination of which I am indebted to Kew, is a native of Uruguay and the Argentine. Mr. Sim notes that it is abundant at Edendale. I have no information as to the circumstances under which it was introduced.

V. pulchella is easily distinguished from other South African species by the presence of the glandular appendages of the anthers.

Gen. CLERODENDRON, Linn.

Clerodendron (§ Cyclonema) pilosum, sp. n.

Suffrutex stirpibus pilosis tenuibus adscendentibus subangularibus ab collo subterraneo ligneo ortis. *Folia* opposita, petiolata, membranacea, late ovata vel triangulari-ovata, basim rotundata vel vix attenuata, apice obtusa vel rotundata, marginibus integris, pilosa præsertim nervis marginibusque. *Cymæ* axillares, 1–2-floræ. *Flores* pedicellis pilosis suffulti; bracteolæ 2, oppositæ, lineares. *Calyx* subanthesin campanulatus (? tandem accrescens), 5-angularis, 5-lobatus, extus pilosus intus glandulifer. *Corollæ* tubus rectus, in faucibus villosus; lobi, superiores oblongi ellipticive, apice rotundati; anterior late spathulatus, concavus. *Ovarium* 4-lobatum, glanduliferum, cæterum glabrum.

Eastern Region: Transkei Division; Kentani, *Miss Alice Pegler*, 164, *in Herb. Kolbe.*

A pilose undershrub, 30–40 cm. high. *Stems* slender, ascending, subangular, arising from a woody underground rootstock. *Leaves* opposite, broadly ovate or triangular-ovate, rounded or slightly attenuate at the base, obtuse or rounded at the apex, entire, pilose especially on the nerves beneath, 2·3–2·4 cm. long, 1·4–1·9 cm. broad; petiole 2–3 mm. long. *Cymes* 1–2-flowered, in the axils of the leaves. *Pedicels* slender, pilose, 1–1·4 cm. long. *Bracteoles* 2, opposite, linear, 1 mm. long. *Calyx* during flowering campanulate, 5-angled, 5-lobed, pilose without, glandular within; tube 2·5 mm. long; lobes oblong or oblong-lanceolate, equalling the tube. *Corolla-tube* straight, villous in the throat, otherwise glabrous, hardly exceeding the calyx-tube; posterior lobes oblong or elliptic, rounded

at the apex, 4 mm. long; anterior broadly spathulate, concave, 5 mm. long. *Ovary* glandular, otherwise glabrous. Drupe not seen.

C. pilosum is related to *C. hirsutum* (Pearson in *Fl. Cap.* l.c. 221) from which it is separated by its broad ovate leaves, straight corolla-tube, and perfectly glabrous ovary. These may, however, prove to be extreme forms of a very variable species.

CLERODENDRON (§ CYCLONEMA) REFLEXUM, sp. n.

Frutex ramis subangularibus, striatis pubescentibus. *Folia* opposita vel subopposita, petiolata, membranacea, ovata, oblonga vel subrhomboidea, basim cuneata, apice acuta vel plus minusve apiculata, marginibus alte serratis vel inciso-serratis (lobis multis paucisve, latis, subapiculatis) vel infra medium (rarius omnino) integris, puberula, nervis principiis lateralibus adscendentibus 4–6 utrinque. *Panicula* terminalis bracteata, pauciflora, pedunculata. *Bracteæ* bracteolæque parvæ, polymorphæ. *Flores* pedicellis tenuibus brevibus suffulti. *Calyx* subanthesin campanulatus, tandem accrescens, alte 5-lobatus, pubescens, profuse glandulifer; lobi tum recti, tum patentes, denique reflexi, oblongi, apice obtusi vel rotundati. *Corollæ* tubus arcuatus, extus glaber, intus præsertim in faucibus villosus; lobi oblongi, patentes, apice rotundati. *Stamina* longe exserta. *Ovarium* obscure 4-lobatum glanduliferum, glabrum. *Drupa* 4-lobata.

TROPICAL AFRICA: Rhodesia; Bulawayo, *Eyles*, 1006, *in Herbb. MacOwan, Bolus.*

A pubescent shrub with subangular striate branches. *Leaves* opposite or subopposite, petioled, ovate oblong or subrhomboid, acute or more or less apiculate, cuneate at the base, deeply serrate or inciso-serrate with broad subapiculate lobes or entire below the middle (rarely along the whole margin), 5–9·5 cm. long, 2–5·5 cm. broad; petiole 1·2 cm. long. *Panicle* terminal, few-flowered; peduncle 3–5 cm. long. *Flowers* shortly pedicelled. *Calyx* campanulate during flowering, accrescent, deeply 5-lobed, pubescent and profusely gland-dotted, 4 mm. long; lobes oblong, at first erect, later reflexed, obtuse or rounded at the apex, 3 mm. long. *Corolla-tube* curved, glabrous without, villous within especially in the throat, about 1 cm. long. *Stamens* far exserted. *Ovary* gland-dotted. *Drupe* 4-lobed, about 1 cm. in diam.

This species is allied to *C. Wilmsii* from which it may be distinguished by its deeply lobed calyx and its larger leaves which are not gland-dotted.

FURTHER NOTE ON FACTORIZABLE CONTINUANTS.

By Thomas Muir, LL.D.

(Read September 28, 1904.)

1. The main result contained in the previous note * was a generalisation embracing as special cases a theorem of Sylvester's and a theorem of Painvin's, Sylvester's theorem for the sixth order being

$$\begin{vmatrix} a & 1 & . & . & . & . \\ 5 & a & 2 & . & . & . \\ . & 4 & a & 3 & . & . \\ . & . & 3 & a & 4 & . \\ . & . & . & 2 & a & 5 \\ . & . & . & . & 1 & a \end{vmatrix} = (a^2 - 1^2)(a^2 - 3^2)(a^2 - 5^2).$$

The mode of treatment consisted in the removal of the factors, one by one, in the sequence

$$a+5, \quad a+3, \quad a+1, \quad a-1, \quad a-3, \quad a-5,$$

each removal being followed by a lowering of the order of the determinant.

2. To this an alternative course has since been found which, though not more effective in the matter of demonstration, has unexpectedly led to a new theorem of greater interest than that under consideration. Instead of removing one factor, advantage is taken of the fact that the continuant in question is centro-symmetric, and therefore is expressible as the product of two determinants of the third order, viz., in the form

$$\begin{vmatrix} a & 1 & . \\ 5 & a & 2 \\ . & 4 & a+3 \end{vmatrix} . \begin{vmatrix} a & 1 & . \\ 4 & a & 2 \\ . & 5 & a-3 \end{vmatrix}.$$

* *Trans. S. A. Phil. Soc.*, xv. (1904), pp. 29–33.

The second of the two is not really different in type from the first, where the integers 1, 2, 3, 4, 5 in a manner *envelop* three equal elements; for if the first be $f(a)$, the second is

$$= -\begin{vmatrix} -a & -1 & . \\ -5 & -a & -2 \\ . & -4 & -a+3 \end{vmatrix} \quad = -\begin{vmatrix} -a & 1 & . \\ 5 & -a & 2 \\ . & 4 & -a+3 \end{vmatrix}$$

$$= -f(-a).$$

Both, however, are essentially different from Sylvester's, and yet, from the nature of their connection with Sylvester's, are of necessity resolvable into linear factors. As a matter of fact the factors of the first are $a+5$, $a-3$, $a+1$: and there is suggested the general theorem

$$\begin{vmatrix} a & 1 & . & \ldots\ldots & . & . \\ 2n-1 & a & 2 & \ldots\ldots & . & . \\ . & 2n-2 & a & \ldots\ldots & . & . \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots \\ . & . & . & \ldots\ldots & a & n-1 \\ . & . & . & \ldots\ldots & n+1 & a+n \end{vmatrix}_n = (a+\overline{2n-1}).(a-\overline{2n-3}) \quad (a)$$
$$.(a+2n-5).(a-\overline{2n-7})$$
$$\ldots\ldots\ldots\ldots\ldots\ldots$$

Trial being made upon this it is found that the method followed in the former paper suffices to effect the resolution, the set of line-multipliers employed being

$$\begin{array}{cccccccccc} 1, & 1, & 1, & 1, & 1, & 1, & 1, & 1, & \ldots\ldots \\ & 1, & -1, & 2, & -2, & 3, & -3, & 4, & \ldots\ldots \\ & & 1, & 1, & 3, & 3, & 6, & 6, & \ldots\ldots \\ & & & 1, & -1, & 4, & -4, & 10, & \ldots\ldots \\ & & & & 1, & 1, & 5, & 5, & \ldots\ldots \\ & & & & & 1, & -1, & 6, & \ldots\ldots \\ & & & & & & 1, & 1, & \ldots\ldots \\ & & & & & & & 1, & \ldots\ldots \\ & & & & & & & & \ldots\ldots \end{array} \quad (S)$$

and every multiplier therefore of the form $C_{r+s,\,s+1}$. We are thus brought face to face with the problem of finding the most general continuant resolvable by means of this set of multipliers.

3. The first result obtained is: *If the continuant*

$$\begin{vmatrix} a & \beta_1 & . & \ldots\ldots \\ \gamma_1 & a+p & \beta_2 & \ldots\ldots \\ . & \gamma_2 & a+q & \ldots\ldots \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots \end{vmatrix}$$

be resolvable into linear factors by means of the set of column-multipliers (S), *then*

$$\begin{array}{lllll} \beta_1+\gamma_1 & = \beta_3+\gamma_3 & = \beta_5+\gamma_5 & = \ldots\ldots \\ \beta_2+\gamma_2 & = \beta_4+\gamma_4 & = \beta_6+\gamma_6 & = \ldots\ldots \end{array} \qquad \text{(I.)}$$

Of the truth of this there is no doubt, but a really short proof of it is much to be desired.

Calling the constant in the case of the odd suffixes s, and in the other case t, we may consequently write the continuant in the form

$$\left|\begin{array}{cccc} a & \beta_1 & . & \ldots\ldots \\ s-\beta_1 & a+p & \beta_2 & \ldots\ldots \\ . & t-\beta_2 & a+q & \ldots\ldots \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots \end{array}\right|_n;$$

and when we perform upon this the first operation

$$\mathrm{col}_1 + \mathrm{col}_2 + \mathrm{col}_3 + \ldots\ldots$$

we find, by reason of the removability of the factor $a+\beta_1$, that

$$\begin{array}{l} p = \beta_1 - s + \beta_1 - \beta_2, \\ q = \beta_1 - t + \beta_2 - \beta_3, \\ \ldots\ldots\ldots\ldots\ldots\ldots \end{array}$$

and that the resulting determinant can be lowered in order, being in fact

$$\left|\begin{array}{cccc} a+\beta_1-s-\beta_2 & \beta_2 & . & \ldots\ldots \\ t-\beta_2-\beta_1 & a+q & \beta_3 & \ldots\ldots \\ -\beta_1 & s-\beta_3 & a+r & \ldots\ldots \\ -\beta_1 & . & t-\beta_4 & \ldots\ldots \\ -\beta_1 & . & . & \ldots\ldots \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots \end{array}\right|_{n-1}.$$

By the performance on this of the second operation, viz.

$$\mathrm{col}_1 - \mathrm{col}_2 + 2\,\mathrm{col}_3 - 2\,\mathrm{col}_4 + 3\,\mathrm{col}_5 - 3\,\mathrm{col}_6 + \ldots\ldots$$

and the use of the fact that another factor is thus made removable we obtain a set of $n-2$ equations, which turn out to be sufficient for the complete solution of our problem. The equations involve all the β's and s and t, that is, in all $n+1$ quantities; and the key to the proper mode of treating the set lies in the selection of the three quantities in terms of which the others are most conveniently expressible. These three are s, t, β_1; but even with this fact in possession the solution merits some attention in detail.

The equations are best written in the form

$$\left.\begin{array}{lllllll}
-\beta_1 - s + 2t & = 4\beta_2 - 3\beta_3 & & & & & \\
\beta_1 + s & = 4\beta_2 + 3\beta_3 - 4\beta_4 & & & & & \\
-\beta_1 - 2s + 4t & = 4\beta_2 & + 4\beta_4 - 5\beta_5 & & & & \\
\beta_1 + 2s & = 6\beta_2 & & + 5\beta_5 - 6\beta_6 & & & \\
-\beta_1 - 3s + 6t & = 6\beta_2 & & & + 6\beta_6 - 7\beta_7 & & \\
\beta_1 + 3s & = 8\beta_2 & & & & + 7\beta_7 - 8\beta_8 & \\
\cdots\cdots & \cdots\cdots & \cdots\cdots & \cdots\cdots & \cdots\cdots & \cdots\cdots & \cdots\cdots
\end{array}\right\}$$

and a little examination of them shows the need for considering two cases, viz., n even, and n odd.

4. Let us consider first the case where $n = 2m$. Here the last β is β_{2m-1}, and the last equation

$$\beta_1 + (m-1)s = 2m\beta_2 + (2m-1)\beta_{2m-1}.$$

Taking the first equation of the set, an equation derived by addition from the first two, an equation similarly derived from the first three, and so on, we obtain the following equivalent set

$$\left.\begin{array}{ll}
-\beta_1 - s + 2t = 4\beta_2 - 3\beta_3, & \\
 & 2t = 8\beta_2 - 4\beta_4, \\
-\beta_1 - 2s + 6t = 12\beta_2 - 5\beta_5, & \\
 & 6t = 18\beta_2 - 6\beta_6, \\
-\beta_1 - 3s + 12t = 24\beta_2 - 7\beta_7, & \\
 & 12t = 32\beta_2 - 8\beta_8, \\
\cdots\cdots & \cdots\cdots \\
 & 2(1 + 2 + \ldots + \overline{m-1})t = 2m^2\beta_2.
\end{array}\right\}$$

From the last of the set we have

$$\beta_2 = \frac{m-1}{2m}t,$$

and substitution of this in the others gives

$$\begin{array}{ll}
\beta_3 = \frac{1}{3}\left(\beta_1 + s - \frac{1.2}{m}t\right), & \beta_4 = \frac{m-2}{2m}t, \\
\beta_5 = \frac{1}{5}\left(\beta_1 + 2s - \frac{2.3}{m}t\right), & \beta_6 = \frac{m-3}{2m}t, \\
\beta_7 = \frac{1}{7}\left(\beta_1 + 3s - \frac{3.4}{m}t\right), & \beta_8 = \frac{m-4}{2m}t, \\
\cdots\cdots & \cdots\cdots \\
\beta_{2m-1} = \frac{1}{2m-1}(\beta_1 + \overline{m-1}.s - \overline{m-1}.t), & \beta_{2m-2} = \frac{1}{2m}t.
\end{array}$$

From these the γ's are readily calculable, and thereafter p, q, r, ... from the β's and γ's. Doing this, and putting, for neatness' sake, $a = a + \frac{1}{2}t$ and $t = 2\tau$, we reach the following general theorem :—

The continuant of the $2m$th *order*

$$\begin{vmatrix} A_1 & \beta_1 & . & ..... \\ \gamma_1 & A_2 & \beta_2 & ..... \\ . & \gamma_2 & A_3 & ..... \\ ..... & & & \end{vmatrix}$$

is resolvable into linear factors if, putting M *for* $2b - s + \frac{1}{m}\tau$, *we have*

$$A_1 = a + \tau, \quad A_{2\theta} = a + \frac{\theta}{2\theta - 1}M, \quad A_{2\theta+1} = a + \frac{\theta}{2\theta + 1}M;$$

$$\beta_1 = b, \qquad \beta_{2\theta} = \frac{m - \theta}{m}\tau, \qquad \beta_{2\theta+1} = \frac{1}{2\theta+1}\left\{\theta s + b - \frac{2\theta(\theta+1)}{m}\tau\right\};$$

$$\gamma_1 = s - b, \quad \gamma_{2\theta} = \frac{m + \theta}{m}\tau, \qquad \gamma_{2\theta+1} = \frac{1}{2\theta+1}\left\{(\theta+1)s - b + \frac{2\theta(\theta+1)}{m}\right\};$$

the factors being

$$\begin{aligned} &\left(a + b + \tau \right) . \left(a + b - s - \tau + \frac{2}{m}\tau\right) \\ . &\left(a + b + \tau - \frac{2}{m}\tau \right) . \left(a + b - s - \tau + \frac{4}{m}\tau\right) \\ . &\left(a + b + \tau - \frac{4}{m}\tau \right) . \left(a + b - s - \tau + \frac{6}{m}\tau\right) \\ &..... \\ . &\left(a + b + \tau - \frac{2m-2}{m}\tau\right) . \left(a + b - s - \tau + \frac{2m}{m}\tau\right). \end{aligned} \qquad \text{(II.)}$$

5. It is worth noting that

$$\begin{aligned} 1\text{st factor} &= (1, 1) \qquad + (1, 2), \\ 2\text{nd factor} &= (2, 2) - (1, 2) - (2, 3), \\ 3\text{rd factor} &= (3, 3) + (2, 3) + (3, 4), \\ 4\text{th factor} &= (4, 4) - (3, 4) - (4, 5), \\ &..... \\ (2m)\text{th factor} &= (2m, 2m) - (2m - 1, 2m), \end{aligned}$$

where the elements of the continuant are denoted by their place-names (1, 1), (1, 2), ...; also, that the sum of any even-numbered

factor and the factor immediately following it is $2a+2b-s$, thus giving for the sum of all the factors

$$(a+b+\tau)+(m-1)(2a+2b-s)+(a+b-s-\tau),$$

$$i.e., \quad m(2a+2b-s)+2\tau.$$

Similarly we note that the sum of the first and second diagonal elements, and the sum of any other odd-numbered diagonal element and the element immediately following it, is $2a+\mathrm{M}$, the result being that the sum of all the diagonal elements is

$$m(2a+\mathrm{M})+\tau,$$

$$i.e., \quad m(2a+2b-s)+2\tau.$$

6. Putting s, which occurs only in the even-numbered factors of (II.), equal to $2b+\frac{1}{m}\tau$ we deduce from (II.) the identity

$$\begin{vmatrix}
a+\tau & b & . & . & . & . & \ldots\ldots \\
b+\frac{1}{m}\tau & a & \frac{m-1}{m}\tau & . & . & . & \ldots\ldots \\
. & \frac{m+1}{m}\tau & a & b-\frac{1}{m}\tau & . & . & \ldots\ldots \\
. & . & b+\frac{2}{m}\tau & a & \frac{m-2}{m}\tau & . & \ldots\ldots \\
. & . & . & \frac{m+2}{m}\tau & a & b-\frac{2}{m}\tau & \ldots\ldots \\
\ldots\ldots & & & & & & \ldots\ldots
\end{vmatrix}_{2m}$$

$$\begin{aligned}
= &\left(a+b+\tau \quad\right) . \left(a-b-\tau+\frac{1}{m}\tau\right) \\
. &\left(a+b+\tau-\frac{2}{m}\tau \quad\right) . \left(a-b-\tau+\frac{3}{m}\tau\right) \\
. &\left(a+b+\tau-\frac{4}{m}\tau \quad\right) . \left(a-b-\tau+\frac{5}{m}\tau\right) \\
&\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\
. &\left(a+b+\tau-\frac{2m-2}{m}\tau\right) . \left(a-b-\tau+\frac{2m-1}{m}\tau\right).
\end{aligned} \qquad \text{(III.)}$$

Specialising still further by putting $b=2m-1$, and $\tau=2m$, we come back to the simple result (a) from which we started in § 2.

7. The similar investigation of the case where the continuant is of odd order leads to the following theorem :—

The continuant of the $(2m-1)$th *order*

$$\begin{vmatrix} A_1 & \beta_1 & . & \ldots\ldots \\ \gamma_1 & A_2 & \beta_2 & \ldots\ldots \\ . & \gamma_2 & A_3 & \ldots\ldots \\ \ldots\ldots & & & \end{vmatrix}$$

is resolvable into linear factors, if, putting

$$R \equiv s + \frac{1}{m-1}b, \quad N \equiv \frac{2m-1}{m}\left(\frac{2m}{m-1}b - R\right)$$

we have

$$A_1 = a + \tau, \quad A_{2\theta} = a + \frac{\theta}{2(2\theta-1)}N, \quad A_{2\theta+1} = a + \frac{\theta}{2(2\theta+1)}N;$$

$$\beta_1 = b, \qquad \beta_{2\theta} = \tau - \frac{\theta}{2m}R, \qquad \beta_{2\theta+1} = \frac{m-\theta-1}{m(2\theta+1)}\left\{\frac{m}{m-1}b + \theta R\right\};$$

$$\gamma_1 = s - b, \quad \gamma_{2\theta} = \tau + \frac{\theta}{2m}R, \qquad \gamma_{2\theta+1} = \frac{m+\theta}{m(2\theta+1)}\left\{(\theta+1)R - \frac{m}{m-1}b\right\};$$

the factors being

$$\begin{aligned} &\left(a+b+\tau \quad\right) . \left(a+b-\tau-s+\frac{1}{m}R\right) \\ . &\left(a+b+\tau-\frac{1}{m}R\right) . \left(a+b-\tau-s+\frac{2}{m}R\right) \\ . &\left(a+b+\tau-\frac{2}{m}R\right) . \left(a+b-\tau-s+\frac{3}{m}R\right) \\ &\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ . &\ldots\ldots\ldots\ldots\ldots\ldots . \left(a+b-\tau-s+\frac{m-1}{m}R\right) \\ &\left(a+b+\tau-\frac{m-1}{m}R\right). \end{aligned} \qquad \text{(IV.)}$$

Here we have to note that

$$A_{2\theta-1} + A_{2\theta} = 2a + \tfrac{1}{2}N,$$

and hence that

$$A_1 + A_2 + \ldots + A_{2m-1} = (2m-1)(a+b) - (m-1)s + \tau,$$

—a result readily verified by looking at the sum of the factors.

There are at least two interesting special cases, viz., when $s = -\frac{1}{m-1}b$, and when $s = -\frac{2m-1}{m-1}b$. With the former substitution we reach the identity

$$\begin{vmatrix} a+\tau & (m-1)\beta & . & . & . & . & \ldots\ldots \\ -m\beta & a+\frac{1}{2}\mathrm{H} & \tau & . & . & . & \ldots\ldots \\ . & \tau & a+\frac{1}{6}\mathrm{H} & \frac{1}{3}(m-2)\beta & . & . & \ldots\ldots \\ . & . & -\frac{1}{3}(m+1)\beta & a+\frac{1}{3}\mathrm{H} & \tau & . & \ldots\ldots \\ . & . & . & \tau & a+\frac{1}{5}\mathrm{H} & \frac{1}{5}(\mathrm{M}-3)\beta & \ldots\ldots \\ \ldots\ldots & & & & & & \end{vmatrix}_{2m-1}$$

$$= (a+\tau+\overline{m-1}.\beta)^m(a-\tau+m\beta)^{m-1}, \text{ where } \mathrm{H} = (4m-2)\beta; \quad \text{(V.)}$$

and with the latter the identity

$$\begin{vmatrix} a+\tau & (m-1)\beta & . & . & . & . & \ldots\ldots \\ m\beta & a & \tau-\beta & . & . & . & \ldots\ldots \\ . & \tau+\beta & a & (m-2)\beta & . & . & \ldots\ldots \\ . & . & (m+1)\beta & a & \tau-2\beta & . & \ldots\ldots \\ . & . & . & \tau+2\beta & a & (m-3)\beta & \ldots\ldots \\ \ldots\ldots & & & & & & \end{vmatrix}_{2m-1}$$

$$= (a+\tau+\overline{m-1}.\beta)(a-\tau-\overline{m-2}.\beta)(a+\tau+\overline{m-3}.\beta)\ldots\ldots \quad \text{(VI.)}$$

which degenerates into the original on putting $\beta = 2\mathrm{B}$, and $\tau = (2m-1)\mathrm{B}$.

8. On returning to the two main results, (II.) and (IV.), it is readily seen that, although the two continuants seem to be functions of four variables, viz., a, b, s, τ, this is not really so, because the right-hand members are expressible in terms of three variables only. In the case of the even-ordered continuant these latter variables are $a+b$, s, τ, and in the other case $a+b+\tau$, $s+\frac{1}{m-1}b$, $s+2\tau$. Putting therefore $\tau = 0$, $s = 0$, $a = -b$ in (II.), and $s = -2\tau$, $b = 2(m-1)\tau$, $a = -(2m-1)\tau$ in (IV.), we obtain the corresponding nil-factor continuants, that is to say, continuants whose matrices may be added to the matrices of the continuants in (II.) and (IV.) without affecting the identities. For example, knowing that the continuant

$$\begin{vmatrix} a+4 & 3 & . & . \\ 5 & a & 2 & . \\ . & 6 & a & 1 \\ . & . & 7 & a \end{vmatrix} = (a+7)(a-5)(a+3)(a-1),$$

we can assert that, ξ being any quantity whatever, the derived continuant

$$\begin{vmatrix} a+4+\xi & 3-\xi & . & . \\ 5+\xi & a-\xi & 2 & . \\ . & 6 & a+\frac{1}{3}\xi & 1-\frac{1}{3}\xi \\ . & . & 7+\frac{1}{3}\xi & a-\frac{1}{3}\xi \end{vmatrix}$$

has exactly the same value. Thus, taking for ξ the value 3, which causes two of the elements to vanish, we have the new continuant

$$= (a+7)(a-1) \cdot \begin{vmatrix} a-3 & 2 \\ 6 & a+1 \end{vmatrix},$$

$$= (a+7)(a-1) \cdot (a-5)(a+3).$$

The elements of the nil-factor continuants corresponding to the set of column-multipliers (S) *of* § 2 *are for the* $(2m)$*th order*

$$\left.\begin{array}{lll} A_1 = \xi, & A_{2\theta} = -\dfrac{1}{2\theta-1}\xi, & A_{2\theta+1} = \dfrac{1}{2\theta+1}\xi, \\ \beta_1 = -\xi, & \beta_{2\theta} = 0, & \beta_{2\theta+1} = -\dfrac{1}{2\theta+1}\xi, \\ \gamma_1 = \xi, & \gamma_{2\theta} = 0, & \gamma_{2\theta+1} = \dfrac{1}{2\theta+1}\xi, \end{array}\right\} \qquad \text{(VII.)}$$

and for the $(2m-1)$*th order*

$$\left.\begin{array}{lll} A_1 = -2(m-1)\xi, & A_{2\theta} = \dfrac{2m-1}{2\theta+1}\xi, & A_{2\theta+1} = -\dfrac{2m-1}{2\theta+1}\xi, \\ \beta_1 = 2(m-1)\xi, & \beta_{2\theta} = \xi, & \beta_{2\theta+1} = \dfrac{2(m-1-\theta)}{2\theta+1}\xi, \\ \gamma_1 = -2m\xi, & \gamma_{2\theta} = \xi, & \gamma_{2\theta+1} = -\dfrac{2(m+\theta)}{2\theta+1}\xi, \end{array}\right\} \text{(VIII.)}$$

9. When the nil-factor matrix (VII.) is added to the matrix of (II.) in §4, the element in the place (1, 2) is $b-\xi$, and the element in the place $(2m-1, 2m)$ is $\dfrac{1}{2m-1}\left\{b+\overline{m-1} \cdot s-\overline{m-1} \cdot \tau\right\} - \dfrac{1}{2m-1}\xi$. Both elements will therefore vanish when $x = b$ and $s = \tau$, and it will be possible to remove the first and last factors from both sides, thus giving a new continuant of the $(2m-2)$th order equal to the

product of the remaining factors. Doing this, and writing A for $a+b-\tau$, we arrive at the identity

$$\begin{vmatrix} A+\frac{1-m}{m}\tau & \frac{m-1}{m}\tau & . & . & . & \ldots\ldots \\ \frac{m+1}{m}\tau & A+\frac{1+m}{3m}\tau & \frac{2}{3}\cdot\frac{m-2}{m}\tau & . & . & \ldots\ldots \\ . & \frac{4}{3}\cdot\frac{m+1}{m}\tau & A+\frac{2-m}{3m}\tau & \frac{m-2}{m}\tau & . & \ldots\ldots \\ . & . & \frac{m+2}{m}\tau & A+\frac{2+m}{5m}\tau & \frac{4}{5}\cdot\frac{m-3}{m}\tau & \ldots\ldots \\ . & . & . & \frac{6}{5}\cdot\frac{m+2}{m}\tau & A+\frac{3-m}{5m}\tau & \ldots\ldots \\ \ldots\ldots & & & & & \ldots\ldots \end{vmatrix}_{2m-2}$$

$$=\left(A-2\tau+\frac{2}{m}\tau\right).\left(A+2\tau-\frac{2}{m}\tau\right)=\left\{A^2-\left(\frac{m-1}{m}.2\tau\right)^2\right\}\ldots\left\{A^2-\left(\frac{1}{m}.2\tau\right)^2\right\}$$
$$.\left(A-2\tau+\frac{4}{m}\tau\right).\left(A+2\tau-\frac{4}{m}\tau\right)$$
$$\ldots\ldots\ldots\ldots\ldots\ldots \qquad \text{(IX.)}$$
$$.\left(A-2\tau+\frac{2m-2}{m}\tau\right).\left(A+2\tau-\frac{2m-2}{m}\tau\right)$$

Here the general expressions for the elements are

$$\left.\begin{aligned} A_{2\theta-1} &= A+\frac{\theta-m}{(2\theta-1)m}\tau, & A_{2\theta} &= A+\frac{\theta+m}{(2\theta+1)m}\tau, \\ \beta_{2\theta-1} &= \frac{m-\theta}{m}\tau, & \beta_{2\theta} &= \frac{2\theta}{2\theta+1}\cdot\frac{m-\theta-1}{m}\tau, \\ \gamma_{2\theta-1} &= \frac{m+\theta}{m}\tau, & \gamma_{2\theta} &= \frac{2(\theta+1)}{2\theta+1}\cdot\frac{m+\theta}{m}\tau; \end{aligned}\right\}$$

but as the set of column-multipliers necessary for effecting the resolution is easily ascertained to be

$$\begin{array}{cccccccc} 1, & -1, & 2, & -2, & 3, & -3, & \ldots\ldots \\ & 1, & 1, & 3, & 3, & 6, & \ldots\ldots \\ & & \ldots\ldots & & & & \end{array}$$

that is to say, the set (S) deprived of its first line, a more general theorem than (IX.) is obtainable by means of the procedure of §§ 3, 4.

When τ is put equal to m in (IX.) we obtain a result which on one side closely resembles Sylvester's.

10. On glancing back at the preceding paragraphs it will be seen that the new results obtained have arisen naturally out of an investigation of the accidentally discovered identity (a) of § 2, where the continuant is of such a form that it may be not inaptly described as consisting of a diagonal of identical elements ensheathed by the first $2n-1$ integers, and where the factors into which it is resolvable form not one equidifferent series but two.

Now there is another factorizable continuant, having some of these characteristics, which is equally interesting in itself and equally full of promise as a base for investigation, viz.,

$$\begin{vmatrix} a & \frac{(2n-1)\beta}{2n-1} & . & \ldots\ldots & . & . \\ \frac{1.(\beta+2n-2)}{3-2n} & a & \frac{(2n-2)(\beta+1)}{2n-3} & \ldots\ldots & . & . \\ . & \frac{2(\beta+2n-3)}{5-2n} & a & \ldots\ldots & . & . \\ . & . & \frac{3(\beta+2n-4)}{7-2n} & \ldots\ldots & . & . \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots \\ . & . & . & \ldots\ldots & a & \frac{(n+1)(\beta+n-2)}{3} \\ . & . & . & \ldots\ldots & \frac{(n-1)(\beta+n)}{-1} & a+\frac{n(\beta+n-1)}{1} \end{vmatrix}$$

$$= (a+\beta)\,(a+\beta+2)\,(a+\beta+4)\,\ldots\ldots\,(a+\beta+2n-2). \qquad \text{(X.)}$$

Here in the sheath enclosing the diagonal of a's we have, as in the previous case, the integers 1, 2, 3, ..., $2n-1$ going round the one way, but we have also accompanying them as multipliers the quantities β, $\beta+1$, $\beta+2$, ..., $\beta+2n-2$ going round the reverse way, and accompanying the latter as divisors the integers $2n-1$, $2n-3$, ..., 1, -1, -3, ..., $-(2n-3)$.

Using the fact that the right-hand side of (X.) is a function not of a and β separately, but of $a+\beta$, we find the corresponding nil-factor continuant to be

$$\begin{vmatrix} -\xi & \frac{2n-1}{2n-1}\xi & . & \ldots\ldots & . & . \\ \frac{1}{3-2n}\xi & -\xi & \frac{2n-2}{2n-3}\xi & \ldots\ldots & . & . \\ . & \frac{2}{5-2n}\xi & -\xi & \ldots\ldots & . & . \\ . & . & \frac{3}{7-2n}\xi & \ldots\ldots & . & . \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots \\ . & . & . & \ldots\ldots & -\xi & \frac{n+1}{3}\xi \\ . & . & . & \ldots\ldots & \frac{n-1}{-1}\xi & -\xi+\frac{n}{1}\xi \end{vmatrix}, \qquad \text{(XI.)}$$

and we are thus able to simplify the original identity into

$$\begin{vmatrix} A & \frac{1.2n}{2n-1} & . & \ldots\ldots & . & . \\ \frac{(2n-1).2}{3-2n} & A & \frac{2(2n-1)}{2n-3} & \ldots\ldots & . & . \\ . & \frac{(2n-2).3}{5-2n} & A & \ldots\ldots & . & . \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots \\ . & . & . & \ldots\ldots & A & \frac{(n-1)(n+2)}{3} \\ . & . & . & \ldots\ldots & \frac{(n+1)n}{-1} & A+\frac{n(n+1)}{1} \end{vmatrix}$$

$$= (A+2)\,(A+4)\,(A+6)\,\ldots\ldots\,(A+2n). \qquad \text{(XII.)}$$

Unfortunately the set of column-multipliers necessary for effecting this resolution is not simple, the first line of it being

$$1,\quad 2-\frac{1}{n},\quad 3-\frac{3}{n},\quad 4-\frac{6}{n},\quad \ldots\ldots,\quad n-\frac{n(n-1)}{2n}.$$

August 21, 1904.

ON SOME NEW GENERA AND SPECIES OF HYMENOPTERA FROM CAPE COLONY AND TRANSVAAL.

By P. Cameron.

(Read September 28, 1904.)

This paper is based on species collected for me by the Rev. J. A. O'Neil at Dunbrody, at Pearston and Stellenbosch by Prof. Robert Broom; on species in the Collection of the Albany Museum, Grahamstown, collected by Mrs. G. White, Mrs. Pringle, and Misses Daly and Sole in the neighbourhood of Grahamstown, for the loan of which I am indebted to Dr. S. Schönland; and a few species from the Transvaal in my own Collection.

Family ICHNEUMONIDÆ.

HEMITELINI.

CÆNOAULAX, gen. nov.

Metanotum with one transverse curved keel, its spiracles small, circular. Mesonotum trilobate, transversely striated. Scutellum roundly convex, its sides on the basal half keeled. Clypeus separated from the face, its apex rounded and narrowed. Mandibles bi-dentate; the sub-apical tooth small, the apical long and sharply pointed. Mesosternum furrowed laterally on the basal half. Wings without an areolet, the transverse cubital nervure very short, the cubitus and radius almost touching where it unites them; the recurrent nervure is received beyond it. Transverse median nervure received shortly behind the transverse basal. Transverse median nervure in hind wings broken below the middle; the radius obsolete from near the base; the cubitus entirely so. Legs slender, the claws sparsely combed. First abdominal segment sessile; becoming gradually widened from the base to the apex; longer than it is wide in the middle; the spiracles placed near the apical third. The basal three segments are strongly closely longitudinally striated;

shortly behind the middle of the first and second and in the middle of the third is a wide deep transverse furrow; the third and fourth segments laterally have the apical half roundly curved in the centre, the apex distinctly projecting; there are seven segments.

Antennæ 25-jointed; the first joint of flagellum not quite so long as the second. Eyes large; the ocelli widely separated from them—by the same distance they are from each other; they reach to the top of the vertex. Face and clypeus densely clothed with longish white pubescence.

In Ashmead's system this genus would come in near *Allocota*, Foer. The deep transverse furrows on the abdomen remind one of the Braconid genus, *Iphiaulax*.

Cænoaulax striatus, sp. nov.

Dark rufous, the head, breast, and legs black; antennæ black, dark rufous at the base; front legs dark testaceous, the hind tibiæ with a clear white band on the base; the calcaria pale; wings clear hyaline, the nervures and stigma black; the apical abdominal segments white. ♀.

Length 6 mm.; terebra 1 mm.

Cape Colony. Grahamstown, April.

Head rugosely punctured; sparsely haired on the front and vertex, the rest thickly covered with long clear white pubescence; from the ocelli stout striæ run obliquely backwards to the eyes. Hind ocelli separated from each other by about the same distance they are from the eyes. Thorax covered with white pubescence; the mesonotum transversely striated; a narrow longitudinal furrow in the centre of the middle lobe. Scutellum roundly convex, coarsely rugosely punctured. Base of metanotum rugose; the apical slope slightly but distinctly hollowed, obscurely transversely striated; its edges keeled. Pleuræ closely rugosely punctured; the apex of the pro- stoutly striated. Basal two segments of the abdomen stoutly, longitudinally striated; the third and fourth rugosely punctured, irregularly striated; the apical segments smooth. Palpi long, white. Base or mandibles rufous. Legs covered with a white pile. The long spur of the hind tibiæ does not reach to the middle of the metatarsus; it is as long as the second joint.

LIENELLA, gen. nov.

Metanotum with fifteen areæ in three rows; the base obliquely depressed in the middle. Wings without an areolet; the transverse cubital nervure short, not much longer than broad; the recurrent

nervure about three times its length from it. Transverse median nervure interstitial. Transverse median nervure in hind wings broken distinctly below the middle; the radius and cubitus faint. Forewings spotted. Antennæ at least 18-jointed (the apical joints are broken off); pilose; the second joint of flagellum longer than the third. Eyes large; malar space small. Hind ocelli clearly separated from the eyes; they are separated from them by a less distance than they are from each other. Occiput margined. First abdominal segment long (as long as the following two segments united), slender, not much dilated at the apex; the spiracles near the middle; the middle of the post-petiole keeled; the second and third segments closely, strongly longitudinally striated. Sternal furrow wide, deep. Legs long, slender, the tarsi closely spinose below; claws simple. Temples broad, obliquely narrowed. Occiput margined.

The affinities of this species are with *Cænoaulax* here described. It is easily separated by the areolated metanotum, longer and more slender abdominal petiole, and by the absence of transverse furrows on the basal segments.

Lienella nigriceps, sp. nov.

Rufous, antennæ, except the scape and basal joints of flagellum, head, breast, median segment, except the base of the pleuræ, and the base and apex of the abdomen black. Legs rufous, the anterior paler, more yellow in tint. Wings clear hyaline, the nervures and stigma black; there is a brown cloud which extends from shortly behind the base of the radius to shortly beyond the middle of the radial cellule and posteriorly to the discoidal nervure. ♂.

Length 6 mm.

Cape Colony. Dunbrody, February 17th.

Front closely, roundly striated; a square fovea in the middle below. Vertex closely, finely obliquely striated. Mesonotum closely striated; obliquely at the base, the rest transversely; apex of middle deeply longitudinally furrowed. Scutellar depression wide, deep. Scutellum rugosely punctured. The base of the first central area smooth, its apex closely transversely striated, the second punctured, the outer rugose; the central outer reticulated; the others with a few irregular keels. Pro- and meso-pleuræ punctured and irregularly striated; the meta- closely, rugosely punctured. Post-petiole with some fine longitudinal striæ; the second and third segments closely, strongly longitudinally striated. Hind coxæ and femora punctured, thickly covered with white hair.

PIMPLINI.

COSMIOPIMPLA, gen. nov.

Transverse median nervure in hind wings broken distinctly below the middle. Areolet oblique, of equal width, longer than broad, shortly appendiculated at the first transverse cubital nervure; disco-cubital nervure broken by a stump of a nervure, sharply angled. Apex of clypeus obliquely depressed, slightly rounded. Last joint of antennæ nearly as long as the preceding two united. Fore claws with a stout tooth at the base. Abdominal segments broader than long, coarsely, closely punctured, and with transverse furrows. Wings large, yellowish-hyaline, with fuscous clouds. Eyes emarginate within. Ovipositor elongate, straight.

In Ashmead's arrangement (Bull. U.S. Nat. Mus., xxiii., 57) this genus would come in near *Pimpla* and *Notopimpla*, but these may be known by the transverse median nervure in hind wings being broken above the middle, in addition to the other differences.

Cosmiopimpla ferruginea, sp. nov.

Ferruginous, flagellum of antennæ, apical third of hind tibiæ and the hind tarsi black; wings yellowish-hyaline, a broad fuscous cloud immediately beyond the transverse median and transverse basal nervures, narrowed slightly in front and extending from the costa to the opposite side, a slightly narrower cloud extending from the base of the stigma to the areolet, and backwards to the apex of the wing, thence proceeding along the apex, upwards to the costa; hind wings fuscous, yellowish-hyaline to near the middle and having a yellowish hyaline cloud in the centre of the apical fuscous part, wide in front, gradually narrowed behind; the stigma and nervures in the yellow part luteous. Head and thorax smooth and shining; the base and sides of metanotum sparsely, distinctly punctured; the basal four segments of abdomen closely, strongly punctured; the others smooth; the furrows wide and deep. ♀.

Length 12 mm.; terebra 8 mm.

Cape Colony. Brak Kloof.

Gen. PIMPLA, Fab. sec. Ashm.

Pimpla limbata, Tosq.

This species is in the Collection from Jannerill (Miss Lippan). It cannot be referred to *Pimpla* as now defined. It might be referred to *Cosmiopimpla* if it were not that the apex of the clypeus is transverse and slightly depressed, and the fore claws not toothed at the base.

Tribe LISSONOTINI.

Gen. LISSONOTA, Grav.

Lissonota interstitialis, sp. nov.

Black, the abdomen red, the apices of the basal three segments narrowly yellow; the eye orbits all round, the face, clypeus, mandibles, and palpi yellow, the face with a black line down the centre, becoming wider towards the apex and extending round the top of the clypeus. On the centre of the mesonotum are two broad lines, which are triangularly dilated on the outer side at the base, the apical two-thirds of the propleuræ above, the lower side more narrowly yellow, the two lines being united by a broader oblique line which runs from the base of the upper; a curved irregular line in the centre of the mesopleuræ extending from near the base to the apex, a short line under the hind wings, an elongated ovoid mark on the centre of the metapleuræ, the sides and apex of scutellum, the apical line projecting slightly beyond the lateral ones; and a curved line on the apex of the metanotum, with a conical projection at its base, yellow. Four front legs yellow, tinged with fulvous behind; the hinder red, the coxæ and trochanters yellow, the former broadly black in the middle above; the four posterior tarsi fuscous. Pedicle of the areolet nearly twice the length of the lower branches. ♀.

Length 12 mm.; terebra 7 mm.

Cape Colony. Dunbrody, December.

Head closely and distinctly punctured; the clypeus sparsely punctured above. The thorax is much more coarsely punctured all over and covered with a white pile. The first abdominal segment is shining, sparsely and minutely punctured on the apical half; the others are finely and closely punctured; the apical pilose; the third and fourth are black along the lower part of the sides. The recurrent nervure is interstitial with the second transverse cubital.

Tribe NOTOTRACHINI.

Gen. NOTOTRACHYS, Marshall.

Nototrachys flavomaculatus, sp. nov.

Rufous, the face, clypeus, mandibles, palpi, eye orbits, prothorax, two lines, dilated at the base, on the mesonotum, scutellums, apical slope of metanotum, the mesopleuræ except above the middle, the apex of metapleuræ broadly and the part below the hind wings, pale

yellow; legs rufous, the four front tibiæ paler; the back of the second and following abdominal segments blackish above; antennal scape rufous, the flagellum blackish. Wings hyaline, the stigma and nervures black. ♀.

Length 10 mm.; abdomen 7 mm.; ovipositor 3 mm.

Head smooth, shining; the front keeled down the centre, transversely, closely striated. Mesonotum strongly, irregularly transversely striated, except on the sides at the apex where it is punctured. Scutellum reticulated. Metanotum at the base with a transverse keel, which curves towards the post-scutellum in the middle; this part is almost smooth; the rest of the median segment is closely, strongly reticulated. Propleuræ stoutly, obliquely striated at the base. Basal half of mesopleuræ above longitudinally striated; the apical smooth; the lower punctured-reticulated. Metapleuræ coarsely reticulated. There is a curved keel in front of the middle coxæ and another between it and the posterior. The wings are short, about half the length of the body.

Cape Colony. Dunbrody.

Tribe OPHIONINI.

Gen. LIMNERIUM, Ashm. (LIMNERIA, Auct.)

Limnerium stellenboschense, sp. nov.

Black, shining; antennal scape and legs rufous; all the trochanters, the four front coxæ and the middle of the hind tibiæ pale yellow; the hind coxæ black, a band near the base of the hind tibiæ, a broader one on their apex and the apices of the hind tarsal joints fuscous, the rest of the hind tarsal joints pale; the apices of the basal three abdominal segments rufo-testaceous, as are also the sides of the third and fourth. Wings hyaline, the stigma fuscous, the nervures darker. ♀.

Length 5 mm.; terebra 1 mm.

Cape Colony. Stellenbosch.

Head shagreened, the face not so strongly as the front, and more shining. Palpi yellow. Thorax minutely, closely punctured, the median segment more strongly and less shining than the rest. There are no closed areæ on the metanotum; from near the centre of the base two keels run obliquely to the middle of the segment, which bears silvery-white pubescence. The basal branch of the areolet is as long as the pedicle; the apical is distinctly longer than either; the areolet distinctly projects below; the basal branch of the projection being clearly longer than the apical.

Gen. ASPHRAGIS, Foer.

Asphragis ? rufipes, sp. nov.

Head pale bright yellow, the front and vertex broadly in the centre and the occiput black; the thorax red, the pro- and meta-notum black; abdomen black, the third and fourth segments for the greater part dull rufous above; legs coloured like the thorax, the tarsi darker in tint; wings clear hyaline, the stigma dark fuscous. ♂.

Length 6 mm.

Cape Colony. Stellenbosch.

Scape of antennæ dull red below; basal joints of flagellum elongate; the first slightly longer than the second. Head closely and strongly punctured; the punctures on the front and vertex more distinctly separated than they are on the face; the clypeus, except above, smooth. Mandibles pale yellow, their teeth black, the part behind them rufous. Palpi testaceous. Thorax closely and strongly punctured; scutellar depression smooth and shining; the meta-notum more coarsely punctured than the mesonotum; there is one stout transverse keel on the apical slope; the part on either side of this is irregularly striated. Tibiæ sparsely, the tarsi more thickly spinose; legs long and slender; the fore tarsi longer than the tibiæ. The transverse median nervure is received shortly beyond the transverse basal; the apical nervures in the hind wings are faint; the transverse cubital nervure is broken below the middle.

This may not be an *Asphragis*, which has the claws closely pectinated, whereas here the pectinations are few and widely separated.

Gen. CHAROPS, Holmgren.

Charops spinitarsis, sp. nov.

Black; the four anterior legs bright yellow, the hinder dark red, their tibiæ and tarsi darker coloured than the femora; all the coxæ black; the basal joint of hind femora black, the apical yellow; the abdomen rufous, blackish above; wings clear hyaline, the nervures and stigma blackish. ♀.

Length 10 mm.

Cape Colony. Stellenbosch.

Head and thorax covered thickly with white pubescence, the pubescence longest on the face and outer eye orbits. Head and thorax closely and distinctly punctured. Propleuræ strongly striated, the striæ distinctly separated, except above; the hollowed middle and the apex of the mesopleuræ are less strongly striated; the upper part of the metapleuræ is irregularly obliquely striated,

especially above, where there is a keel down the middle. On the basal half of the metanotum are two longitudinal keels which converge slightly below; on either side of them, at the base, is a large area, wider than long, obliquely narrowed below, the outer part being the larger; the apex of the segment is closely irregularly reticulated. Tibiæ and tarsi spinose. Apex of mandibles and palpi yellowish testaceous. Abdominal petiole curved, as long as the following two segments united, its apex distinctly dilated.

Sub-Family TRYPHONINÆ.

Gen. EXOCHUS, Gravenh.

Exochus ? fuscipilosus, sp. nov.

Black; the head and thorax thickly covered with fuscous pubescence; the face below the antennæ brownish; the greater part of the antennæ testaceous; wings hyaline, the stigma and nervures fuscous; legs bright red. Shining, impunctate. Posterior median area slightly obliquely narrowed at the base; the petiolar area widest at the base. ♂.

Length 4 mm.

Cape Colony. Stellenbosch.

This species is not quite a typical *Exochus*. I therefore give some structural details. On the metanotum are five areæ; the posterior median is narrowed at the base and confluent with the petiolar; the apical slope is surrounded by keels; the spiracular area confluent with the area dentipara. Spiracles on petiole placed close to the base; petiole with two longitudinal keels on the basal half; there is no keel on the second abdominal segment. Malar space large. The small spiracles touch the lower keel of the spiracular area.

Taking this species as typical of *Exochus* that genus may be separated from *Plesioexochus*, described here, as follows :—

Metathoracic spiracles elongate, large; first joint of flagellum much longer than the second; apex of metanotum with an oblique slope .. .. *Plesioexochus.*

Metathoracic spiracles small, oval; first joint of flagellum as long as second; apex of metanotum with a rounded slope .. *Exochus.*

PLESIOEXOCHUS, gen. nov.

Wings without an areolet; transverse basal nervure received distinctly beyond transverse median; transverse median nervure in

hind wings broken far below the middle. Temples narrow, obliquely narrowed; vertex not separated from occiput by a keel. Median segment with, in all, eight areæ; the apex has a sharply oblique slope and is surrounded by stout keels which form one large area. First abdominal segment about twice longer than it is wide at the apex, towards which it becomes gradually wider; in the centre are two longitudinal keels; the spiracles are placed before the middle; second abdominal segments without a keel. Hind tibiæ with two spurs. First joint of the flagellum as long as the following two united. Metanotal spiracles elongate, about three times longer than wide.

This genus comes close to *Exochus*, which may be known from it by the first abdominal segment not having keels, by the temples being well developed, and by the transverse median nervure being interstitial, not widely separated from the basal as in the present genus, these differences being in addition to those just noted.

PLESIOEXOCHUS RUFIPES, sp. nov.

Black, shining, the head and upper part of thorax thickly covered with longish fuscous pubescence; the legs bright red, covered with a white pile; wings hyaline, the nervures and stigma fuscous; the front below the antennæ brown; the greater part of the antennæ fuscous below. ♂.

Length 6 mm.

Cape Colony. Stellenbosch.

Face and clypeus closely, strongly punctured; the apex of the clypeus smooth and shining. Mandibles obscurely tinged with testaceous. Palpi bright testaceous. Propleuræ shining, bare, deeply depressed in the middle. Hind calcaria stout, the longer reaching beyond the middle of the metatarsus. Apices of tarsal joints minutely spined.

FAMILY BRACONIDÆ.

GEN. BRACON, Fab. sec. Ashm.

BRACON WHITEI, sp. nov.

Red; the antennæ, front and vertex, a mark, slightly longer than broad and rounded below, in the top of the face above and the mesonotum, except the sutures behind, black; wings dark fuscous, a large cloud behind the transverse median nervure and reaching from

the costa to the apex of the latter; the middle region of the radial cellule largely, the first cubital cellule entirely, the base and apex of the second, the apical cloud the larger and wider part in front, the black cloud having an irregular apex, longest behind the base of the third cellule, the cloud widest in front; the first discoidal cellule except for a large triangular cloud at the base, a small, less clearly defined, cloud at the apex of the third, the base of the first posterior cellule broadly, and of the second posterior more obscurely, yellowish-hyaline; the base of the stigma luteous, the rest of it and the nervures black. Apical joint of the four hinder tarsi black. ♀.

Length 23 mm.; terebra 40 mm.

Cape Colony. Brak Kloof.

Head and thorax smooth and shining, the face with a yellowish hue, rugose, finely, closely striated on the sides below. Third abscissa of radius longer than the basal two united; the recurrent nervure interstitial. Abdomen with the basal six segments closely rugosely punctured; the area on the second segment triangular, not reaching to the middle of the segment, closely longitudinally striated and surrounded by a less closely, more strongly, more obliquely striated border; there is a narrow, closely longitudinally striated line down the centre of the third, fourth, and fifth segments; there is a large smooth spot on the basal half of the third segment; the transverse furrows on the others are smooth and shining on the sides.

This species, in its strongly punctured abdomen, more resembles *Iphiaulax* than *Bracon*, but it wants the oblique and transverse furrows of that genus.

Bracon stellenboschensis, sp. nov.

Luteous, the antennæ, the ocellar region, the occiput broadly in the centre, apex of mesonotum, middle of metanotum and the meso-sternum black; wings hyaline, the nervures and stigma fuscous. ♀.

Length slightly over 2 mm.; terebra 1 mm.

Hab. Cape Colony. Stellenbosch.

Head and thorax smooth; the centre of metanotum irregularly, rather strongly, obliquely striated. The second, third, and fourth abdominal segments aciculated; metapleuræ covered with long white pubescence; the suturiform articulation closely striated. Palpi pale testaceous. Mandibles testaceous. Third abscissa of radius as long as the basal two united. The second abdominal segment is obscurely, closely striated; it has no central keel nor basal area. Ventral surface pale yellow.

Gen. IPHIAULAX, Foer.

Iphiaulax ornaticollis, sp. nov.

Black; a mark on the malar space, a line on the upper part of the propleuræ, narrow at the base, becoming gradually wider towards the apex and an oblique mark on the lower side at the apex, orange-yellow; wings clear yellowish hyaline to the apex of the stigma, fuscous beyond; the stigma orange-yellow, black at its base and apex; apical abscissa of radius somewhat longer than the basal two united. Palpi black. ♀.

Length 13 mm.; terebra 2 mm.

Cape Colony. Dunbrody.

Antennæ densely microscopical pilose; the scape short, compressed, longer below than its width above, laterally becoming gradually wider towards the apex. Face opaque, closely minutely punctured and covered with long black hair; front and vertex smooth and shining. Temples wide, as long as the antennal scape, not obliquely narrowed, rounded behind. Abdomen as long as the head and thorax; smooth; the middle of the first segment keeled longitudinally, the keel not reaching the apex; the area on second segment triangular, slightly longer than its width at the base; its lateral furrow roundly curved inwardly; an oblique keel on the sides of the third; the furrows are smooth. Hind femora compressed laterally below. The cloud in the hind wings commences shortly beyond the middle.

PARASPINARIA, gen. nov.

Abdomen with seven segments; closely rugosely reticulated, the apical two minutely denticulate; the last bluntly rounded; the suturiform articulation not cleft at the sides; the area on the second segment triangular, reaching to the apex. Mesonotum trilobate, the furrows reaching to the scutellum. Metonotum widely furrowed in the centre. Head cubital, the temples well developed, not obliquely narrowed; the occiput slightly roundly incised. Clypeus convex, roundly narrowed behind, its sides bordered by depressions. Transverse median nervure received beyond the transverse basal; the recurrent nervure received in apex of first cubital cellule; the abscissæ of radius become successively longer, the last roundly curved upwards. Hind wings as in *Exothecus* except that the costal cellule is much more narrowed at the apex, the nervures almost touching there. Antennal scape short, about three times longer than broad; the first joint of flagellum slightly longer than broad.

The stigma is large; the radius issues from shortly behind its middle. Legs of moderate size; the fore claws bifid, the basal tooth the shorter; the other claws simple. Calcaria not reaching to the middle of metatarsus. Malar space large. Eyes parallel, not converging. A stout keel between the antennæ. The ♂ has only six abdominal segments; the apical two are not toothed; the last is broadly rounded at the apex. It is more pilose than the ♀.

The relationship of this genus appears to be with *Spinaria*. That genus has the abdomen differently formed, and with only five segments, the spines, too, being much more conspicuous; the head is smaller, with the temples obliquely narrowed; the antennæ much longer and thinner; the eyes incised on the inner side; the prothorax is much more elongate and narrowed and often spined; and the abdominal segments longitudinally striated. Szepligeti (Termés Fuz. xxiv. 45) describes a genus, *Mesobracon*, from the Congo, which appears to be allied to *Paraspinaria*, but the apical abdominal segments are not spined. As this genus probably extends to Cape Colony I give the full description of it as given by Szepligeti: Head transverse, radial cellule long, not reaching to the apex of the wing, abdomen closely granular-rugose. Seven segments visible, the second with a cental area. At p. 45 *l.c.* it is stated that the abdomen is not spined in the ♀, the only sex described.

Paraspinaria V-ornata, sp. nov.

Black; the apex of the first abdominal segment, the edges of the area on the second segment, forming a V-shaped mark and a line down the centre of the third, fourth, and fifth segments, brown; wings yellowish hyaline to the apex of the stigma, beyond that fuscous, except for a small hyaline cloud on either side of the second transverse cubital nervure, the base of the radial cellule being yellowish hyaline; the apical fourth of the hind wings fuscous. Mandibles rufo-testaceous. ♀ and ♂.

Length 14 mm.; terebra 5 mm.

Cape Colony. Brak Kloof.

Head smooth and shining, the face indistinctly keeled. An oblique fovea or depression on the sides of the clypeus, its apex with an indistinctly crenulated furrow, the edge sharply turned up. Metanotum widely and deeply furrowed in the centre, its sides oblique. First abdominal segment coarsely irregularly reticulated in the centre; the others closely rugosely punctured, the centre irregularly reticulated. The area on the second segment reaches to the apex of the segment and forms a triangle; the transverse

furrows are narrow, deep and striated; the first is not cleft at the sides; there are four furrows of equal width and depth and all closely striated. The third abscissa of the radius is curved and is also long as the second cubital abscissa; the recurrent nervure is received near the apex of the first cubital cellule.

The middle lobe of the mesonotum is clearly separated, especially at the apex where the furrows are broad. Antennal scape short. The sides of the seventh abdominal segment armed with four short teeth; the centre at the apex roundly incised; the sixth segment denticulate all round the apex, the teeth longer and more distinct at the sides, where, on the outer side, they are more widely separated. The apical segments are more distinctly reticulated than the basal. The third segment has a smooth, shining space on the sides near the base; the fourth to sixth with smooth, lateral depressions.

The ♂ wants the teeth on the apical abdominal segments, of which there are only six; the last is broadly rounded at the apex.

Gen. METEORUS, Haliday.

Meteorus capensis, sp. nov.

Black, shining; the coxæ and trochanters testaceous, the femora darker testaceous, the tibiæ and tarsi blackish; wings hyaline, iridescent, the stigma black, the nervures pale. ♂.

Length 4–5 mm.

Cape Colony. Stellenbosch.

Antennæ much longer than the body, fuscous at the base, covered with a close microscopic pile. Head shining, aciculated; malar space with some irregular striæ. Clypeus more strongly aciculated than the face; its sides above bordered by a deep depression, Mandibles brownish; palpi blackish. Middle lobe of mesonotum aciculated, opaque, pilose; the lateral bare and shining; the furrows closely, irregularly rugose. Upper part of mesopleuræ rugose, the oblique depression on the lower half irregularly striated. Median segment coarsely, irregularly rugose, the metanotum almost reticulated; on the upper edge of the pleuræ are two curved keels with some striæ between them. Petiole closely, distinctly longitudinally striated; the other segments smooth and shining. Legs pilose; the pubescence longer and white on the femora, shorter, darker, and closer on the tibiæ and tarsi. Wing nervures pale; the second cubital cellule is distinctly narrowed in front; the transverse median nervure is received shortly beyond the basal; the recurrent shortly in front of the transverse cubital;

both the transverse cubital nervures are bullated on the lower side next to the cubitus.

The petiole is broader than usual and has distinct tracheal grooves; the second cubital cellule is more narrowed in front than it is in most of the species.

CHALCIDIDÆ.

Gen. DIRRHINUS, Dalm.

Dirrhinus ruficornis, sp. nov.

Black, the antennæ and four front legs rufous; the hind tarsi pale testaceous; wings hyaline, suffused with fulvous in the middle. ♂.

Length 3 mm.

Cape Colony. Stellenbosch; Grahamstown.

Head and thorax covered with silvery pubescence. Frontal process longer than the eyes, gradually narrowed into a sharp point; the lower side longer than the upper and with a distinct margin, grooved above; the upper part flat, round, slightly narrowed towards the apex; flat, with the sides raised into a stout border or keel; the head is strongly and closely punctured, the punctures running into reticulations on the process. Clypeus projecting, smooth, bare, shining; its sides stoutly keeled. Pro- and meso-thorax strongly punctured, the scutellum roundly bordered behind; the metapleuræ closely reticulated. Metanotum with stout keels forming areæ; in the centre are two keels which, on the basal half, curve roundly outwardly; the apical half at the top projects obliquely outwards, the rest being only slightly oblique; inside, at the end of the narrowed basal part, is a narrower keel, which curves roundly backwards; the apex is raised and behind is a rounded keel; at the base in the centre is a stout keel, narrowed towards the apex and reaching near to the apex of the narrowed basal part of the area; on the sides is a long area; its outer keel is straight, oblique, the inner curves roundly to the outer keel, with the apex oblique, straight. The abdominal petiole is as broad as long; in the centre are two stout keels; bordered by three narrower ones; the base of the second segment is finely, closely striated. Apex of abdomen trilobate, the middle lobe broader and more rounded than the lateral, which becomes gradually narrowed to a bluntly rounded point.

The sides of the metanotum project into a blunt, oblique tooth, this projecting part being hollowed and striated in the centre.

Assuming that Mr. Kirby's figure of *D. excavatus*, Dal. (a widely-spread African species), is correct, the species here described may be readily known by the central area on the metanotum being much larger and longer, reaching to the apex, whereas in *excavatus* the central area only reaches to the middle and is followed by two larger ones which extend to the sides.

RHYNCHOCHALCIS, gen. nov.

Antennæ inserted over the mouth, 10-jointed, the last longer than the preceding two united. Malar space longer than the length of the eyes. Apex of scutellum with two rounded lobes. Sides of metanotum above with a stout, turned up obliquely, tooth. Ovipositor stout, fully one-third longer than the abdomen, the segments enclosing it reaching shortly beyond the middle. Hind femora greatly thickened, untoothed, pilose below.

The antennæ are short and stout, the scape does not reach to the ocelli; its apex is dilated; the frontal depression at the sides and above clearly keeled, the keel enclosing the front ocellus. Below the eyes the head becomes distinctly, obliquely narrowed, forming a snout. There is a large rounded keel between the antennæ. Malar space keeled on inner side.

In Dr. Ashmead's arrangement (Mem. Carnegie Museum, i., 256) this genus comes nearest to *Hippota*, with which it cannot be confounded in either sex. The very long ovipositor reminds one of *Megachalcis* and *Megacolus*, which, however, do not belong to the *Halticellini*.

Rhynchochalcis niger, sp. nov.

Black, thickly covered with silvery pubescence, the wings fusco-hyaline, the nervures and stigma black. ♀.

Length 8 mm.; terebra 4–5 mm.

Cape Colony. Stellenbosch.

Head opaque, alutaceous; the vertex and outer orbits punctured, the latter more strongly above than below; the orbits and the malar space thickly covered with long silvery pubescence. Clypeus shining, sparsely punctured below and more depressed there than above. A smooth keel runs down from the centre of the eyes to the mandibles. Pro- and meso-thorax strongly punctured, the base of mesopleuræ smooth and shining, the rest opaque, rugosely, closely punctured and densely covered with long fuscous pubescence. The sides and apex of scutellum distinctly margined, the apex in the middle transverse, the sides obliquely narrowed. In the centre of the metanotum are two longitudinal keels; at the base is a row of round foveæ,

bordered by a stout curved keel; the sides are bordered by a stout keel, inside of which are some irregular transverse keels; there are also two or three broken longitudinal keels. Abdomen closely punctured, the base of the segments smooth and shining. The basal part of the ovipositor is closely punctured, the apical smooth. The four front tarsi are covered with testaceous pubescence beneath; their calcarea testaceous; the hind tibiæ keeled on the sides below.

ENCYRTIDÆ.

EUPELMINÆ.

MESOCOMYS, gen. nov.

Antennæ 13-jointed, thickened towards the apical joint, which is long, thick, becomes gradually narrowed, and is hollowed in the middle below; the flagellum sparsely pilose, the second joint four times longer than thick; they are placed not far from the mouth and widely separated from the eyes. Front only slightly excavated in the centre; the vertex roundly, broadly convex. Eyes large, oval; the malar space large; the eyes slightly converge above. Parapsidal furrows narrow, distinct; the centre of the mesonotum raised, broad, rounded behind and separated from the scutellum by an irregularly raised space. Scutellum large, longer than wide, rounded and slightly narrowed at the apex; at its base are two large, deep foveæ, widest at the base, rounded at the apex. Base of metanotum trifoveate, the middle fovea the larger. Pleuræ not excavated. Abdominal segments not incised. Fore femora dilated, narrowed at the base and apex, flattened in front; the four hinder femora more slender and longer, as are also their tibiæ; the basal joint of middle tarsi greatly swollen; the middle tibiæ grooved behind, their spurs much thicker than the anterior or posterior, longer, reaching to the middle of metatarsus. The sub-marginal vein long, reaching to the middle, its apical third curved downwards, thickened and in front thickly margined with longish hair; marginal vein short, not one-fourth of the length of the sub-marginal; radius thick, curved, cleft at the apex, the upper fork short and curved, the lower straight and oblique. Clypeus furrowed in the centre, the furrow widest at the apex. Occiput transverse in the middle, the sides obliquely rounded.

I am not quite certain as to the exact systematic position of this genus. It should be readily known by the densely pilose, curved apex of the sub-marginal vein, by the cleft apex of stigmal branch, by the two large deep foveæ at the base of scutellum and by the three large foveæ at the base of the metanotum.

MESOCOMYS PULCHRICEPS, sp. nov.

Dark purple, mixed with blue and brassy tints; the head dark purple on the sides of the vertex, the centre blue; the front fiery coppery red, the clypeus green; antennæ black, the scape rufo-testaceous; legs black, the tarsi and the fore femora and tarsi in front testaceous; wings hyaline, the middle clouded, except at the base of the marginal vein, where there is a hyaline cloud of equal width. ♀.

Length 3 mm.

Head closely, distinctly punctured, the vertex less strongly than the rest; sparsely pilose. Thorax smooth, the pleuræ very minutely, indistinctly punctured; the furrow on the pronotum testaceous. Ovipositor shortly projecting, testaceous. There is a narrow testaceous band on the base of the middle tibiæ.

Cape Colony. Grahamstown; Brak Kloof.

FOSSORES.

SCOLIIDÆ.

GEN. DIELIS, Sauss.,

DIELIS ERIONOTUS, sp. nov.

Black, thickly covered with long, white woolly pubescence, the clypeus, except for a large triangular mark in the centre, labrum, base of mandibles, a line on the apex of the fore femora and the four anterior tibiæ behind, yellow; the calcaria and tarsal spines white; wings hyaline, the stigma and nervures black. ♂.

Length 18 mm.

Cape Colony. Dunbrody.

The hair on the head and thorax is longer and denser than in most males, it hiding the sculpture; it is sparser on the clypeus which is smooth, impunctate, this appearing to be also the case with the thorax, so far as can be made out through the dense hair covering. The black on the abdomen has a bluish tinge; on the second segment the band is dilated in the middle and still more so laterally; on the third it is narrower but is more distinctly dilated in the middle; in both the lateral expansion extends beyond the middle; the bands on the other segments are narrow and are fringed with golden hair.

SPHEGIDÆ.

Gen. PALARUS, Latr.

Palarus curvilineatus, sp. nov.

Length 11 mm. ♂.

Cape Colony. Steynsburg, January.

Similar in the colouration of the head and thorax to *P. lineatifrons*, but the yellow lines on the abdomen are paler, wanting the rufous tinge; they are much narrower, the basal being also distinctly, roundly curved; the metanotal fovea is larger, it reaching to the base of the segment; it is broader there, is deeper and wants the keels, the alar nervures and stigma are black, not testaceous; the first transverse cubital nervure has not the upper part obliquely bent, and the pygidium is not closely, regularly striated.

There is a smooth line below the lower ocellus; below it is a narrow keel; the larger yellow keel has not a fovea; the lower ocellus almost round, with a curve above the middle. Eyes distinctly converging above, separated there by almost the length of the third and fourth antennal joints. Clypeus shining, only sparsely, weakly punctured. Metanotum closely, strongly punctured, except round the fovea, where there is a broad, rounded, smooth border; the fovea is transverse at the base and half the width it is at the apex. The basal third of the mesonotum is broadly depressed in the middle. The second ventral segment becomes gradually dilated from the base to the apex; the basal two-thirds of the pygidium stoutly keeled in the centre, the sides with some broken, oblique, irregular keels, forming almost reticulations; the apex not depressed. The basal spines are broad, project obliquely outwardly, and are roundly curved on the inner and outer sides; the base with some large punctures, the apex smooth. The basal two yellow abdominal lines are entire, the apical four interrupted in the middle. The cheeks are thickly covered with long silvery-white hair; the front and vertex bear longish white hair; the clypeus is almost bare. Mesonotum and scutellum shining, distinctly, but not closely punctured, the latter smooth in the centre. Median segment, except round the fovea, closely rugosely punctured. The yellow line on the post-scutellum is interrupted in the middle; there are no yellow marks on the scutellum. Legs black; the under side of the four front femora, the tibiæ, and tarsi are yellow; the tibial and tarsal spines are almost white. Tegulæ brownish, with a large yellow spot on the base. The first and second transverse cubital nervures unite

at the top; the upper two-thirds of the first and third transverse cubital nervures are obliquely bent; the first recurrent nervure is received shortly beyond the transverse cubital; the lower part of the apical abscissa of the radius is oblique, the upper straight; the outer branch is shorter than the lower part.

PALARUS LINEATIFRONS, sp. nov.

Black; the inner eye orbits broadly below, narrowly above, antennal keel, a mark, roundly dilated above, in the centre of the face below, clypeus, base of mandibles broadly, a line on the hinder edge of the pronotum, the base of the propleuræ—the mark roundly incised at the apex—a curved mark on the apex above, tegulæ, a mark in front of them, reaching to the lower edge of the mesonotum, a small oblique mark on the base of the mesopleuræ above, a large mark on the base extending from the top to below the middle, broadest above, rounded below, the base of the metapleuræ, the line irregularly waved on the apex, an irregular mark behind the spiracles, a large mark on the apex, its lower half irregularly dilated backwards, two lines on the base of the scutellum and the post-scutellum, pale yellow; the first abdominal segment rufous-yellow, with a somewhat triangular mark in the centre at the apex; the second to fourth segments broadly from behind the middle, the lines dilated at the sides, a narrower line not dilated laterally and almost separated in the middle, the basal two ventral segments, except broadly in the middle, the apices of the others narrowly and irregularly, yellow with a rufous tint. Legs yellow, the greater part of the coxæ, the trochanters, the base of femora all round, their upper part broadly, and the tibiæ behind, black. Wings clear hyaline, the nervures testaceous. ♀.

Length 12–13 mm.

Cape Colony. Somerset East.

Pygidium stoutly, regularly longitudinally striated to near the narrowed apex, which is hollowed. Eyes distinctly converging above, separated there by fully the length of the third and fourth antennal joints. Frontal keel stout, long, rounded above, narrowed towards the apex. Anterior ocellus large, wider than long, widely separated from the posterior. Vertex closely and strongly punctured, the front not so closely nor so strongly, the clypeus sparsely punctured. Mandibles rufous in the centre. The whole head is thickly covered with longish white hair. Pro- and meso-thorax closely and strongly punctured, shining and thickly covered with white pubescence. Scutellum sparsely punctured at the base and

apex. Median segment, except at the base, closely punctured; in the centre of the base is a large, somewhat pyriform fovea, the narrow end at the base. Second cubital cellule almost sessile, the nervures uniting at the top. Tibiæ spinose, the hinder almost serrate behind, the fore tarsi fringed with long stiff spines on the outer side; the hinder have also long stout spines as well as short ones.

The front below the ocelli is roundly raised; immediately behind the dilated part it is furrowed; there is a longish, distinct ovate fovea below the top of the frontal keel; the basal half of the metanotal fovea is not so much depressed as the apical; it has a stout keel in the centre and its sides are also keeled.

Gen. PIAGETIA, Rits.,

Piagetia striata, sp. nov.

Black, the basal four joints of the antennæ, the clypeus except in the middle at the base, mandibles except the teeth, fore legs, the middle in front and the tegulæ, brownish castaneous; wings hyaline, a not very distinct cloud in the basal half of the radial cellule, in the apex of the first cubital, the second and third cubitals, and along both sides of the recurrent nervures. ♀.

Length 9 mm.

Cape Colony. Dunbrody, February.

Hind femora without a tooth. Basal part of metanotum closely, uniformly, and distinctly transversely striated; the apical slope smooth, thickly covered with silvery pubescence; there is a narrow longitudinal keel on the basal half. Lower part of front and clypeus thickly covered with silvery pubescence. Apex of clypeus almost transverse, the middle with a slight shallow incision. Antennal scape as long as the pedicle and first joint of flagellum; the pedicle about three times longer than wide. Head opaque, wider than the thorax; a shallow furrow in the centre of the front and a wider, deeper one on either side of its apical half. Eyes slightly but distinctly converging above. Pleuræ alutaceous, the apex of the meta- irregularly obliquely striated. Tubercles castaneous, fringed behind with silvery pubescence. First abdominal segment becoming gradually wider towards the apex; if anything longer than the second; the penultimate broadly castaneous on the apical half; the pygidium rufo-testaceous, shining, bare, strongly but not very closely punctured, the apical half of hypopygium similarly coloured.

The tibiæ and tarsi are sparsely spined; the spines long and

rufous; the spines on the fore tarsi are slender, as long as the apical joint, and apparently few in number. Mandibles on lower side, behind the incision, broad, transverse. Malar space obsolete. Fore ocelli separated from the posterior three times the distance these are from each other. Median segment clearly longer than it is wide at the base, narrowed towards the apex. There is no depression or furrow on the vertex behind the ocelli.

Allied to *P. kohlii*, Brauns.

Gen. CERCERIS, Latr.,

Cerceris holconota, sp. nov.

Black; clypeus, the inner orbits to the base of antennæ, the spot obliquely narrowed above, cheeks, a conical spot—the rounded part above—below the antennal keel, the basal half of mandibles, a spot on either side of pronotum, an almost interrupted line on post-scutellum, a line, narrowed in the middle on the apex of the third abdominal segment and one of equal width on the apex of the fifth, pale yellow. Legs bright red, the hind coxæ black, the tibiæ yellow on the outer side. Antennal flagellum fulvous, darker above. Wings hyaline, the apical half suffused with smoky tints; the costa and stigma dark testaceous, the nervures black. ♀.

Length 11 mm.

Cape Colony. Dunbrody.

Metanotal area smooth, shining, deeply furrowed in the centre; the apical slope also deeply furrowed. Clypeus flat, its apex broad, transverse, depressed, black. Third joint of antennæ slightly shorter than the first and longer than the fourth. Hinder ocelli separated from each other by about the same distance as they are from the eyes. Front and vertex strongly and closely, the face and clypeus more sparsely punctured. Front with a keel in the centre. Pro- and meso-notum strongly but not closely punctured; the latter broadly depressed in the centre of the basal half, the pleuræ more coarsely, closely, rugosely punctured. Abdomen strongly punctured; the pygidium opaque, granular, the base with some irregular punctures; more narrowed towards the base than to the apex; incision in epipygium reaching to the middle; the penultimate segment broadly raised in the middle, rugose, projecting laterally at the apex and densely covered with white pubescence. The third ventral segment marked with white, narrowly in the middle, broadly laterally.

Allied to *C. nigrifrons*, Sm.

CERCERIS NOBILITATA, sp. nov.

Black; the face, clypeus, the lower half of the inner eye orbits, the base of mandibles broadly, greater part of antennal scape, basal half of tegulæ (the hinder rufous), a large mark, rounded laterally on the base of second segment in the centre, a band on the apex of the third, narrowed in the middle, extending to the base on the sides, and a broad mark on the apical half of the fifth and the sides of the third ventral segment broadly, yellow; the first and the sides of the second segment rufous; legs red; the outer side of the tibiæ and the base of the tarsi whitish yellow; the inner side of the hind tibiæ and the apical joints of the hind tarsi fuscous; wings hyaline, the apex smoky; the stigma and nervures black. ♀.

Length 11 mm.

Dunbrody. Cape Colony.

Front and vertex closely and strongly punctured, the former with a distinct keel. Face and clypeus less closely punctured; the apex of the latter broadly rounded. Hind ocelli separated from each other by a distinctly less distance than they are from the eyes. Thorax strongly, the pleuræ more coarsely, closely rugosely punctured. Metanotal area smooth and shining, indistinctly furrowed in the middle. First abdominal segment sparsely, indistinctly punctured; the others closely and strongly punctured; pygidium opaque, narrowed towards the base and apex, opaque, granular, coarsely at the base, finely at the apex, which is rounded; epipygium with two curved keels on the apex. The flagellum of antennæ brownish, darker above; the scape for the greater part yellow; the third joint distinctly, but not much, longer than the fourth.

CERCERIS SPINICAUDATA, sp. nov.

Black; the clypeus except at the apex, face, the inner orbits broadly half-way to the ocelli, basal half of mandibles, under side of scape, outer half of tegulæ, the greater part of the four front femora, the four front tibiæ and tarsi and the outer side of the hind tibiæ posteriorly, clear yellow. Wings hyaline, the apex slightly smoky; the stigma and nervures black. ♀.

Length nearly 10 mm.

Cape Colony. Pearston.

Metanotal area closely aciculated; a narrow crenulated furrow down the centre; the bordering furrows are also crenulated. Front and vertex rugosely punctured; a narrow furrow on the centre of the former; the antennal keel large, black, yellow above. Face and clypeus strongly, but not so closely punctured as the front; the apex of clypeus transverse, black; the sides rounded. Mandibles yellow,

black at the apex. Hind ocelli separated from the eyes by the same distance as they are from each other. Thorax closely and strongly punctured, the upper parts less closely than the sides. Abdomen strongly punctured; the pygidium closely, irregularly longitudinally reticulated, except at the apex, which is almost transverse; the epipygium ending in two stout, slightly curved piceous spines, which extend backwards to near the middle of the segments as keels.

CERCERIS ALBIGENA, sp. nov.

Black; face, inner orbits broadly to the middle of the eyes, basal half of mandibles, tegulæ, two lines on scutellum, a broad mark on the base of the second abdominal segment, rounded laterally and narrowed at the base in the middle, the apex and sides of the third segment, a narrow interrupted line on the apex of the fourth, a shorter broader one of equal width on the fifth, and a small spot on the sides, whitish-yellow. Legs red, the outer side of the tibiæ white, the inner side of the hinder tibiæ and the hind tarsi infuscated. Wings hyaline, slightly smoky, the nervures and stigma black. ♀.

Length 9 mm.

Cape Colony. Pearston.

Metanotal area smooth, shining; a narrow furrow in the centre, ending in a depression at the apex. Front and vertex closely and distinctly punctured. Hind ocelli separated from each other by a slightly less distance than they are from the eyes; antennal keel large, plate-like, obliquely narrowed at the base and apex and continued above as a narrow keel. Face and clypeus sparsely punctured, flat, the cheeks covered with white hair. Apex of clypeus black, depressed in the middle, transverse, the sides ending in short, bluntly rounded teeth; the sides broadly, roundly incised to near the outer edge. Pronotum rather strongly punctured, broadly depressed in the middle; mesonotum more sparsely punctured and furrowed in the middle at the base, the scutellum still more sparsely punctured. Metanotum regularly punctured, the punctures clearly separated; the apex broadly depressed. Propleuræ irregularly punctured, more strongly above; mesopleuræ strongly and regularly punctured; the metapleuræ aciculated. Abdomen strongly punctured; the first segment thick, about one-fourth longer than thick; its apex narrowly rufous. Pygidium punctured, except at the apex, narrowed roundly at the base, becoming gradually narrowed towards the apex from the basal fourth; the apex bluntly rounded and not half the width of the base; the apical fourth of epipygium roundly incised. The third segment is largely white below.

Cerceris varilineata, sp. nov.

Black; the face, clypeus, the lower inner orbits broadly—the top narrowed and more broadly on the inner side—a mark behind the top of the eyes; a broad, irregular line on the apex of the pronotum, two large marks on the base of the scutellum, dilated on the inner side and more narrowly and longly on the outer at the apex, the post-scutellum, a large, oval mark on the sides of the median segment, a large, irregular mark on the base of the mesopleuræ, extending on to the mesosternum, which it covers entirely, and the apices of the six basal abdominal segments broadly, pale yellow, the base of the third and fourth segments broadly red. Legs bright yellow; the hind femora, apex of tibiæ broadly and the hind tarsi tinged with rufous. Antennæ brownish, the flagellum blackish above, the scape yellow below. Wings hyaline, the apex smoky; the nervures and stigma black. ♂.

Length 8–9 mm.

Cape Colony. Dunbrody.

Front and vertex rugosely punctured; the face and clypeus more sparsely punctured. Apex of clypeus broadly trilobate, the middle lobe broader and longer than the lateral; all their apices rounded, lateral fringe white. Pro- and mesonotum punctured, but not closely, the centre of the latter smooth and with a narrow furrow at the base; the scutellum is more sparsely punctured, the post-scutellum smooth. Metanotal area smooth, bordered by a row of punctures; the centre of apical slope hollowed, smooth. Pleuræ strongly, but not closely, punctured, the apex of the meso- with a broad striated band. Abdomen strongly punctured, the second, third, and fourth segments depressed at the base. Pygidium slightly narrowed towards the apex, which is slightly rufous; the punctures are few and widely separated; apex of epipygium transverse; apices of basal four ventral segments yellow; the middle segments densely pilose.

Cerceris languida, sp. nov.

Black; the clypeus, a small conical mark above its middle, a large mark on the inner eye orbits, roundly narrowed above and below, a small mark broader than long below this, a mark broader than long on either side of the pronotum, tegulæ, an interrupted line on the post-scutellum, a line on the apex of the second abdominal segment, narrowed, almost interrupted in the middle, a broader one, only slightly narrowed on the third, a short mark on the sides of the fourth, and the sixth with a large mark, narrowed laterally, pale yellow; the first abdominal segment red, with a large black mark, rounded

and narrowed at the apex, on the basal three-fourths. Legs black; the fore femora broadly below, a mark on the middle near the apex, the apex of the posterior, the greater part of the four front tibiæ and the outer side of the posterior pale yellow, the four front tarsi fulvous. Wings hyaline, the apex infuscated, the nervures and stigma black. Flagellum of antennæ for the greater part fulvous. ♂.

Length 7 mm.

Cape Colony. Dunbrody, July.

Vertex and upper part of front closely and strongly punctured; the lower part of the front aciculated; the face and clypeus as strongly, but not so closely punctured and covered with silvery pubescence. Clypeus long, obliquely narrowed from above the middle to the apex, which is sharp-pointed. Antennal keel large. Mandibles rufous, black at the point. Thorax strongly and deeply punctured; the median segment more strongly than the rest; the mesonotum with two depressions. Metanotal area smooth, shining, not furrowed in the centre. Abdomen strongly, closely and deeply punctured; pygidium of equal width and bearing some scattered punctures; the epipygium with a short, broad, rounded incision at the apex. The third joint of antennæ is, if anything, shorter than the fourth.

CERCERIS ORNATIVENTRIS, sp. nov.

Black; the second and following segments of the abdomen ferruginous; the sides above and the base below of the fourth, fifth and sixth segments pale yellow; all the coxæ, the basal half of the first and the whole of the second and third femora black, the four front trochanters rufous, the posterior black; antennæ black, the basal three joints entirely and the fourth and fifth below ferruginous; wings uniformly fuscous-violaceous, the stigma and nervures black. Apical half of clypeus, a broad mark on the lower half of the inner orbits, roundly narrowed above and a mark below it, broader than long. Mandibles black, the basal half yellowish. ♀.

Length 13 mm.

Cape Colony. Dunbrody.

Clypeus large, projecting, the apex transverse, the sides straight, not narrowed towards the apex; sparsely punctured; the front and vertex strongly and closely punctured. Mesonotum and scutellum strongly punctured. Metanotum coarsely rugose; the area coarsely, transversely striated. Pleuræ coarsely rugose, the base of metapleuræ with a broad striated band. First abdominal segment coarsely punctured, the others smooth and shining; pygidium large, very slightly

and gradually narrowed towards the apex, which is not transverse, being slightly curved inwardly; the punctuation is close and forms almost reticulations; the incision on epipygium not reaching to the middle, broad, rounded at the base.

Apparently closely related to *C. bicolor*, Sm., from Gambia.

Cerceris oneili, sp. nov.

Black; the head, except the ocellar region and the centre of the front broadly, the hinder edge of the pronotum, tegulæ, the scutellums and two irregular marks on the metanotum, rufous, antennæ rufous, the second and following joints of flagellum black above; abdomen lemon-yellow, the pygidial area rufous, black at the apex; legs lemon-yellow, the tibiæ and tarsi tinged with rufous; wings hyaline, the apex smoky, the costa and stigma fulvous, the nervures darker. ♀ and ♂.

Length 17–18 mm.

Cape Colony. Dunbrody.

Metanotal area shining, sparsely punctured, furrowed down the centre, the apex finely, closely transversely striated. Clypeus shining, roundly convex above, the apex flatter, more depressed, the lower edge depressed, transverse; the sides thickly covered with silvery depressed pubescence. Front and vertex closely and strongly punctured; antennal keel stout. Thorax closely and strongly punctured, the mesopleuræ closely rugose; its apex with a striated belt, the striæ distinctly separated and curved; the base of metapleuræ more finely and closely striated, the striæ becoming longer below. Abdomen strongly punctured; pygidial area longish, narrowed at the base and apex, the sides roundly curved outwardly, the base rugosely punctured, the middle obscurely punctured, the apex almost smooth; the extreme apex depressed, slightly curved inwardly; the outer edges of the segment have a stout curved keel, rounded at the base, straight and oblique at the apex.

The male has the face, clypeus, mandibles, outer orbits on inner side, the sides of front, a mark in its centre, bifurcating round the ocelli, lemon-yellow; the scape and under side of flagellum lemon-yellow, the upper side of latter rufous; the apex of hinder tibiæ black. Face and clypeus strongly punctured, the latter more strongly than the rest; its centre at the apex transverse. Pygidial area strongly, but not closely punctured, except at the apex, which is slightly rounded; epipygium almost transverse, with a transverse furrow not far from the apex. The last joint of the antennæ is as long as the preceding two united, is roundly incised below, the apex

above slightly, below more broadly obliquely truncated. Ventral surface thickly covered with longish silvery pubescence. The basal slope of the first abdominal segment broadly in the centre, its apex and that of the second and third are narrowly black; the ventral segments are tinged with rufous. The clypeal fringe is pale golden; tegulæ yellow; the head and thorax are more thickly covered with white hair than in the female.

The third antennal joint in the male is as long as the scape, in the female it and the second are as long as it together; in the male the hinder ocelli are separated from each other by a slightly greater distance than they are from the eyes, in the female by a less distance.

Col. C. T. Bingham informs me that there is a male of this species in the British Museum from Damaraland.

CERCERIS MELANOSPILA, sp. nov.

Rufous; the front from shortly behind the ocelli, the face below and on either side of the keel, the clypeal and facial sutures, the lower third of the outer orbits, the thorax except the apex of pronotum, tegulæ, tubercles, and the scutellums, the basal slope of first abdominal segment, a line in its centre reaching to the fovea, a triangular mark on the base of the second segment in the centre, the base of the third, fourth and fifth segments narrowly, a line in the centre of the third, the fourth except for a square mark on the sides at the apex, a large mark on the fifth roundly narrowed to the apex, not reaching to the apex of the segment and the ventral segments, broadly, irregularly, black. Wings hyaline, tinged with fulvous, the apex smoky; the stigma and nervures fulvous. ♀.

Length 17 mm.

Cape Colony. Dunbrody, February; Brak Kloof; Grahamstown.

Antennæ rufous; the third joint shorter than the scape and about one-fourth longer than the fourth. Clypeus roundly convex, distinctly projecting beyond the cheeks, the apex roundly narrowed to the middle, which is transverse, with a slight depression in the centre. Front and vertex closely, distinctly punctured; the ocelli separated from the eyes by double the distance they are from each other. The upper two-thirds of the antennal keel distinctly margined, pale yellow. Pro- and meso-notum with scutellums closely rugose; the metanotum more coarsely rugose, its area at the base obliquely, at the apex transversely striated. Mesopleuræ rugose, the pro- and

metapleuræ irregularly striated. First abdominal segment sparsely and strongly, the second and third weakly punctured; pygidium smooth, the apical half black and clearly narrowed, its apex bluntly rounded; epipygium with the apical third incised; this, with the sides, are thickly covered with long stiff fulvous hair.

The male is coloured like the female except that the clypeus, face, and inner eye orbits to near the ocelli are yellow; that the abdominal segments are only slightly marked with black and that the apical joints of the antennæ are black. Apex of clypeus shortly bluntly tridentate, the middle tooth the shorter; the sides fringed with fulvous, stiff pubescence. Pygidium of equal width throughout, finely aciculated, sparsely punctured, its apex transverse, as is also the apex of epipygium.

Cerceris africana, sp. nov.

Black, the abdomen from near the apex of the first segment, the legs except the hind coxæ, antennæ, clypeus, cheeks, the inner orbits from shortly above the antennæ broadly, the mark obliquely narrowed above, the lower two-thirds of the outer orbits, the line dilated obliquely backwards above, and the tegulæ rufous; the mandibles yellowish, black at the apex; wings hyaline, the apex from the end of the radius and of the third transverse cubital nervure smoky; the nervures and stigma fulvous. ♀.

Length 14 mm.

Cape Colony. Dunbrody.

Metanotal area closely and strongly punctured, more closely and not quite so strongly as the rest of the segment. Head and thorax thickly covered with long white pubescence. Third joint of antennæ shorter than the scape and about one-fourth longer than the following. Hinder ocelli separated from each other by a slightly, but distinctly, less distance than they are from the eyes. Clypeus roundly convex, coarsely aciculated, the apical half with longish, clearly separated punctures; its apex in the middle projecting broadly, rounded. Thorax closely and strongly punctured, the scutellum more shining and less closely punctured. First abdominal segment thickly covered with long white hair, black, the apex in the middle narrowly, the sides more broadly rufous; it is strongly, the other segments more closely and less strongly punctured. Pygidium coarsely, irregularly wrinkled, except at the apex; it is slightly narrowed towards the base; apex of epipygium with an incision which is slightly longer than it is wide at the apex.

There is an obscure rufous line on the sides of the pronotum, an obscure rufous streak runs from the ocelli to the antennal keel, which is yellowish, bordered by rufous. The depressed base of the second and third segments black; the second segment may be broadly black at the base and the fifth narrowly; the antennæ may have the apical joints black above.

CERCERIS PEARSTONENSIS, sp. nov.

Black, a broad line, roundly narrowed above and below, on the centre of the inner eye orbits, antennal keel, a line on the outer side of the pronotum, tegulæ, post-scutellum, the third abdominal segment except for a broad curved black band in the centre of the base and a broad, irregular band on the apical half of the fifth, yellow; the first segment and the second, except for a broad curved mark on its apex, red; legs black; the greater part of the fore femora and the four front tarsi rufous; all the tibiæ white on the outer side. Flagellum of antennæ for the greater part brownish. Wings hyaline, the apex smoky. ♀.

Length 9 mm.

Cape Colony. Pearston.

Third antennal joint shorter than the scape and about one-quarter longer than the fourth. Front and vertex closely and strongly punctured. Face and clypeus thickly covered with silvery pubescence; the face and base of clypeus sparsely punctured; the apex of clypeus obliquely incised; the sides of the incision straight, forming a sharp angle in the centre and sharply projecting below, the lower edges forming sharp teeth; the lateral edges roundly, broadly incised, the apical roundly projecting. Mandibles yellowish at the base, reddish in the centre, black at the apex. Pro- and meso-notum distinctly punctured, the punctures clearly separated; the scutellum more sparsely punctured; pleuræ closely, coarsely rugosely punctured. Metanotal area longer than its width at the base, smooth; a row of deep punctures down the centre, the punctures close to each other and wider than long. Pygidium slightly narrowed towards the base and apex; slightly, irregularly, obliquely striated; its apex oblique, bordered by a rounded keel above; apex of epipygium with a rounded incision, not extending to the middle.

The amount of red on the second abdominal segment varies, it may be present on the extreme base, or the segment may be entirely red. Comes near, apparently, to *C. albifrons*, Sm., of which the male only has been described very imperfectly.

CERCERIS VARICINCTA, sp. nov.

Black; the face, clypeus, a band on the apex of the third and fourth abdominal segments, narrowest in the middle and the whole of the fifth, pale yellow, the first segment and a mark on the side of the second at the base, rufous. Antennæ rufous, darker above. Legs rufous, the four front tibiæ pale yellow on the inner side, the posterior broadly above; hind tarsi blackish. Wings fuscous, violaceous, the nervures and stigma black. ♀.

Length 11–12 mm.

Cape Colony. Dunbrody; Pearston.

Third joint of antennæ not much longer than the fourth. Front and vertex closely and strongly punctured, the face and clypeus more sparsely and less strongly. Apex of clypeus broad, transverse; the face and clypeus covered with silvery pubescence. Hind ocelli separated from each other by a less distance than they are from the eyes. Thorax strongly punctured; the punctures large and clearly separated. Metanotal area smooth, raised, furrowed down the middle. Abdomen strongly punctured; the pygidium on the basal half covered closely with broken, irregular, longitudinal striæ; the apical irregularly, longitudinally, striated and rufous; the incision on epipygium about three times longer than wide, of equal width and rounded at the base.

CERCERIS RUFICAUDA, sp. nov.

Black, the inner orbits broadly from the base of the antennæ, antennal keel, clypeus, cheeks, a spot, rounded at the base, transverse at the apex, in the centre of the first abdominal segment, a minute one on the apex of the second, a broad band, roundly narrowed in the centre, on the apex of the third, the centre of the fifth broadly and the third ventral segment broadly, yellow. Tegulæ and legs bright red, the hind coxæ black, their coxæ yellow. Antennæ black, their basal five or six joints red. Pygidium red, broadly black at the base. Wings hyaline, the radial and cubital cellules smoky-violaceous; stigma and nervures black. ♀.

Length 7 mm.

Cape Colony. Stellenbosch; Brak Kloof.

The third antennal joint is as long as the scape and about one-fourth longer than the fourth. Front and vertex closely and strongly punctured. Hind ocelli separated from each other by a slightly less distance than they are from the eyes. Face and clypeus strongly, but not closely punctured; the apex of the latter broadly rounded; black, mandibles red, black at the apex. Thorax strongly punctured,

the upper part with the punctures larger and more widely separated. Metanotal area hollowed in the centre, the sides stoutly, irregularly, obliquely striated. Pygidium strongly, deeply punctured, of equal width throughout, the apex roundly incised, the sides forming teeth. Epipygium not incised down the middle.

Cerceris whiteana, sp. nov.

Length 11 mm. ♀.

Cape Colony. Brak Kloof, June.

Very similar to *C. holconota;* may be known by the metanotal area not being furrowed, by the metanotum being neither so closely nor so strongly punctured, by the mesonotum and scutellum being much more weakly and sparsely punctured, by the apex of the clypeus not projecting so much, it being consequently not much longer than its width at the apex, while in *holconota* it is distinctly longer than its width at the apex, which is not quite transverse as in *holconota*, but slightly roundly, broadly projecting in the middle with the sides tuberculate; the band on the third abdominal segment is narrow in the middle, broad at the sides where it extends to the base of the segment; there is a thin line on the centre of the fourth segment and a shorter, thicker one on the fifth; there are no marks on the pronotum and a narrow line on the scutellum; there is no distinct mark above the face; tegulæ red; under side of flagellum brownish, as is also the under side of the scape; there is no distinct keel on the front. In *holconota* the mesonotum is distinctly depressed in the centre, which is not the case here. The colouration, other than in the points noted, is the same.

Cerceris nigrifrons, Sm.

Specimens from Brak Kloof agree fairly well with Smith's colouration description. The species is variable in colouration; the two yellow marks on the face mentioned by Smith may be absent; the legs vary in the amount of black on them; the abdominal petiole may be for the greater part black. As usual no mention is made by Smith of the sculpture of the metanotal area and of the pygidal area; the former is strongly striated, the striæ being stout and clearly separated; the lateral is of equal width, transverse at the apex and strongly and deeply punctured. The epipygium is almost transverse at the apex; the penultimate segment is produced laterally at the apex into sharp teeth. Apex of clypeus broadly rounded; the lateral fringe golden. The female I have not seen, nor had Smith.

Gen. DASYPROCTUS, Lep.

Dasyproctus schönlandi, sp. nov.

Black; the greater part of the antennal scape, an interrupted band on the pronotum, an irregular roundish mark on the sides of the scutellum at the base, two irregular lines, widest on the outer side, behind the middle of the second abdominal segment and a broad line, narrowed laterally, on the basal half of the fifth segment, yellow; the four front femora except at the base, their tibiæ and tarsi, the apex of the hind femora and the hind tibiæ on the inner side and the hind tarsi, rufous, largely suffused with black. Wings hyaline, the apex of the radial cellule smoky, the nervures and stigma black. ♀.

Length 8 mm.

Cape Colony. Grahamstown, November.

Front and vertex opaque, the former with shallow punctures which become stronger below; antennal depression bordered above by a narrow, but distinct keel, below which it is smooth and shining. Face and clypeus covered with silvery pubescence; finely rugose; the clypeus ends in two stout, widely separated teeth. Mandibles rufous, yellow at the base above, the apex black. Mesonotum and scutellum bare, opaque; in the middle is a distinct furrow which reaches from the base to near the middle; there is a shorter, indistinct one on either side of the middle; the apex at the scutellar depression irregularly longitudinally striated; the apex of the scutellum bordered by a deep, irregularly striated furrow. Post-scutellum closely rugose, irregularly, closely striated. Median segment finely rugose, irregularly, obliquely striated, the striæ more distinct and widely separated at the base; the segment is short, its apex widely and deeply furrowed. Pro- and meso-pleuræ opaque, with a few scattered punctures. Metapleuræ shining, thickly covered with a silky pile, obscurely, closely, obliquely striated; the apex on the lower part bordered by a stout keel, behind the lower half of which is a deep, oval fovea or depression. The abdominal petiole is as long as the following three segments united, its apical third distinctly dilated. The inner spur of the hind tibiæ is broad, gradually dilated towards the middle above, *i.e.*, narrowed towards the base and apex, pallid yellow, as long as the metatarsus; the hind tibiæ have a few longish pale spines; the legs covered with a silvery pile.

Gen. OXYBELUS, Latr.

Oxybelus spiniferus, sp. nov.

Black; the under side of the antennal scape, the hind edge of the pronotum to the tubercles, two large marks on the base of the

scutellum, extending to shortly beyond the middle, two large marks on the first abdominal segment extending from the basal slope to the apex and narrowed on the inner side, a broad band on the apex of the second, narrowed and almost interrupted in the centre, and narrower lines on the following three segments, yellow. Scutellar plate large, twice longer than wide, its apex bilobate, the lobes rounded and slightly narrowed at the apex; the basal half black, the apical yellow, suffused with rufous, the centre keeled, the sides with some oblique keels. The basal half of the scutellum is deeply furrowed in the centre, the edges of the furrow bordered; its sides keeled, roundly curved, ending in a sharp point, the whole forming a broad lobe rounded and margined on the inner side; in the centre is a keel which projects into a spine at the apex. On the centre of the metanotum are two keels, which unite at the apex; the basal half of the area thus formed is irregularly, widely reticulated; the apex is smooth and hollowed; the sides are margined, the basal half bears some irregular oblique keels. Pleuræ strongly, closely punctured. The hair on the thorax is thick, white, tinged with fulvous. Back of abdomen strongly, closely punctured; the base of the segments with smooth, narrow transverse furrows. Pygidium not much narrowed towards the apex, which is smooth, almost transverse. From the apices of the sides of the dorsal five segments projects a stout, oblique, longish, slightly curved white spine. Legs yellow; all the coxæ and trochanters, the four front femora broadly above and the hind femora, except at the apex, clear yellow. Wings hyaline, the costa and nervures black. Flagellum brownish below. Lower part of front, face, and clypeus thickly covered with silvery pubescence. Mandibles yellow, rufous at the apex.

Length 6 mm. ♀.

Cape Colony. Stellenbosch.

Gen. SCELIPHRON, Klug. (PELOPOEUS, Auct.).

Sceliphron? leptogaster, sp. nov.

Black; the apex of petiole, the penultimate abdominal segment except the basal half above and the last segment testaceous; the four front legs rufo-testaceous, the fore tarsi paler; the posterior tibiæ tinged behind with testaceous; hind spurs testaceous; head and thorax thickly covered with silvery pubescence; wings hyaline, the nervures blackish. Tarsal spines white. ♂.

Length 17 mm.

Cape Colony. Dunbrody, February.

This species may form the type of a new genus or sub-genus. I

know, unfortunately, only the male. It is more slenderly built than usual; the petiole is as long as the rest of the abdomen together; it is 2-jointed, with the apex dilated; it is straight, not curved; the last segment is sharp-pointed and is as long as the preceding two united. Scutellum furrowed in the middle. Temples roundly narrowed. Tarsi sparsely spined; the tibiæ with very few spines; fore tarsi more than twice the length of the tibiæ, the basal two joints being together as long as the tibiæ; the middle tarsi are nearly as long, but their tibiæ are longer. The second cubital cellule longer than the third, more so in front than behind. Claws simple. Pronotum short, wider than long. Head aciculated, the sides of the vertex in front, and the front strongly but not closely punctured; the clypeus with fine scattered punctures; its apex almost depressed. Pro- and meso-notum shining; the former finely and sparsely, the latter more closely and strongly punctured. Scutellum punctured like the mesonotum except in the depressed middle. Post-scutellum not depressed, strongly punctured. Metanotum rugose, widely furrowed down the middle of the basal region before the apical slope; the furrow transversely striated. Propleuræ smooth, shining, bare; the meso- and metapleuræ punctured, more strongly below than above; densely pilose. Abdomen smooth; the petiole longer than the head and thorax united. The second cubital cellule in front is about one-fourth longer than behind, equal in length with the third; the first recurrent nervure is received near the apex of the basal fourth of the cellule; the second nearer the apex. The apical nervures in hind wings are faint, almost obsolete; accessory nervure appendiculated.

This species shows an approach to the Neotropical genus *Podium*.

CEROPALIDÆ.*

Gen. ANOPLIUS, Ashm.

Anoplius whiteanus, sp. nov.

Black; the antennæ and legs rufous; the under side of the scape yellow, the rest black; the coxæ, trochanters, and base of femora broadly black; the tarsi paler coloured; the apices of the joints black, testaceous behind the black apex; wings yellowish hyaline, smoky from shortly beyond the third transverse cubital and the recurrent nervures. ♂.

Length 11 mm.

Cape Colony. Brak Kloof.

* Olim *Pompilidiæ*. *Pompilus* is preoccupied.

The third transverse cubital cellule is triangular, the nervures uniting in front; the upper half of the third transverse cubital nervure is obliquely bent; the first recurrent nervure is received not far from the apex, the second in the middle of the cellule; the transverse median nervure received very shortly beyond the transverse basal, almost interstitial; accessory nervure in hind wings received beyond the cubitus. Covered with a fulvous, pale pile; the antennal scape, sides and front of head, and, to a less extent, the top of the thorax with long fuscous hair. Mandibles, except at apex and the apical half of labrum, rufous. Palpi testaceous, darker at the base. Apex of clypeus transverse, the sides roundly oblique. Eyes slightly incised above the middle. Hind ocelli separated from the eyes by a slightly less distance than they are from each other. Occiput transverse. Temples almost obsolete above. Prothorax large, obliquely dilated from the middle to the tegulæ. Apex of metanotum with an oblique, straight slope, and thickly covered with longish blackish hair. Abdomen with broad, pruinose bands, the apical segment white above. Tarsal and tibial spines long and black; the long spur of hind tibiæ two-thirds of the length of the metatarsus. The antennal joints roundly dilated below. Tegulæ fulvous. The first and second joints of flagellum equal in length.

This is an *Anoplius* as now limited.

ANOPLIUS ? PULCHRIHIRTUS, sp. nov.

Dark ferruginous, the greater part of the pleuræ, metanotum, a line above each antennæ, a mark on the ocelli, obliquely narrowed behind and incised in front, black; a line on the hinder edge of the pronotum and on the base of the second and third abdominal segments, pale lemon-yellow. Wings hyaline, slightly tinged with fulvous, the apex smoky; the stigma testaceous. ♀.

Length 9 mm.

Cape Colony. Stellenbosch.

Eyes distinctly converging above; the hinder ocelli separated from each other by a distinctly greater distance than they are from the eyes. Apex of clypeus broadly rounded. Third joint of antennæ not quite so long as the following two united. Apex of pronotum broadly rounded, with a narrow furrow in the middle. Metanotum covered with purple-coppery coloured depressed pubescence, as are probably also, in fresh examples, all the pleuræ. The spines on the legs are long and coloured like them; those on the fore tarsi are much longer; the under side of the posterior spinose; the claws bifid. Third abscissa of radius half the length of the second; transverse basal nervure interstitial; the recurrent nervures are received

near the apical third of the cellule; the accessory nervure in hind wings received beyond the cubitus. The eyes converge distinctly above and below, reach to the base of the mandibles; median segment with a broadly rounded slope and not furrowed in the centre. The long spur of the hind tibiæ reaches beyond the middle of metatarsus. Labrum furrowed in the middle. Mandibles with a long curved apical tooth.

This species does not fit very well into any of Dr. Ashmead's genera of *Anoplini*. I therefore leave it, for the present, in *Anoplius* (*Pompilus*) in the old sense.

DIPLOPTERA.

Gen. ICARIA, Sauss.

Icaria capensis, Sauss.

What I take to be this species is in the Grahamstown Museum Collection from Douglas. The worker only has been described. The female is similarly coloured, and 12–13 mm. long. The male has the lower part of the front, the face, clypeus, and mandibles yellow; the antennæ are blackish above, testaceous and yellow below; the sixth to twelfth joints project below, forming a serrated edge; the projections on the eighth to eleventh are sharper, more oblique and distinct than on the others; the last joint is curved, stout, distinctly narrowed at the apex. It is a variable species as regards colouration; there may be three large black marks on the mesonotum; the pleuræ may be for the greater part black, and there may be a yellow line on the first abdominal segment. The radial cellule may be clouded.

Gen. SMITHIA, Sauss.

Smithia ? rufipes, sp. nov.

Black; the under side of the antennal scape, clypeus, a line on the apex of the pronotum, the tegulæ and the apex of the basal two abdominal segments yellow; legs rufous, flagellum of antennæ fuscous, darker above; wings hyaline, tinged with fuscous violaceous. ♂.

Length 7 mm.

Cape Colony. Brak Kloof.

Head closely and coarsely punctured; the clypeus sparsely punctured; its apex black, depressed; it is roundly convex, sparsely pilose. Pro- and meso-thorax closely, strongly punctured. Median

segment (including the pleuræ) alutaceous and thickly covered with silvery pubescence. Tegulæ large, conchiform, longer than broad. Abdominal petiole as long as the thorax. First transverse cubital nervure oblique, roundly curved downwards, the second not oblique, roundly curved outwardly; the third straight; the first and second transverse cubital nervures almost touching in front; second recurrent nervure received near the apex of the cellule.

In *S. natalensis* the second cubital cellule is clearly appendiculated.

Gen. RHAPHIGLOSSA, Saunders,

Rhaphiglossa flavo-ornata, sp. nov.

Black; a curved line on the top of the clypeus, a spot on the inner side of the eye incision, a line on the under side of the antennal scape, a line on the apex of the pronotum, a small mark, longer than broad, on the scutellum on the sides, two large lines on the post-scutellum, two oblique marks on the apex of the metanotum, two triangular marks on the apex of the first abdominal segment, a narrow line on the apex of the second, lines in the centre of the following three at the apex and a somewhat triangular mark (the broad end at the base) on the last, pale yellow; two small reddish-yellow marks on the vertex above the antennæ; a broad rufous mark on the vertex behind, broad above, below reaching to the end of the eyes, becoming narrowed gradually below; the sides of the propleuræ narrowly above, the apex and middle broadly and a line behind the middle of the abdominal petiole red. Legs of a brighter red colour, the fore coxæ black; the tibiæ pale yellow on the outer side, the hind tarsi infuscated. Wings fuscous-violaceous, the stigma and nervures black. Basal half of antennæ red. Basal half of mandibles red on the inner side. ♀.

Length 15 mm.

Cape Colony. Dunbrody.

Head closely and strongly punctured, more closely on the front than elsewhere; covered with a white down. Apex of clypeus almost transverse in the middle, the sides projecting into large leaf-like expansions, roundly curved on the outer side, narrowed towards the apex, the outer border raised, the inner side straight. Thorax closely, rugosely punctured; the centre of the metanotum almost smooth, keeled down the middle. Metapleuræ sparsely punctured behind the middle and at the apex. Abdominal petiole faintly punctured, the other segments smooth and covered with a white pile. Petiole longer than the other segments united.

This species cannot well be confounded with *R. natalensis*, Sm.

Gen. ODYNERUS.

Odynerus (leionotus) whiteanus, sp. nov.

Black; the clypeus, mandibles, except at the apex, the outer orbits almost entirely, the sides of the vertex broadly behind, antennæ, except the apical eight joints above, pronotum, scutellum, post-scutellum, the sides of the median segment broadly, an irregular spot on the base of the mesopleuræ above, the sides and apex of the basal two segments of the abdomen (the black basal mark large, broad at the base and narrowed in the centre), and the other segments almost entirely, red; the centre and the lower part of the eye incision, a mark above the antennæ, broader than long and slightly incised in the middle above, the sides of the clypeus above, a band on the apex of the pronotum, narrowed laterally, a small curved mark on the inner, hinder edge of the tegulæ, the raised hinder inner edge of the scutellum, the apex of the first abdominal segment above and of the second all round, yellow. Legs red, the knees and the four hinder tibiæ on the outer side pale yellow. Wings fuscous-hyaline, the radial cellule and the apex all round darker violaceous; stigma dark testaceous, the nervures black. ♀ and ♂.

Length 11–12 mm.

Cape Colony. Grahamstown, February; Brak Kloof.

Head closely and strongly punctured. Antennæ placed below the middle of the face. Clypeus slightly longer than its greatest width, its centre irregularly, longitudinally striated, the oblique sides punctured, the apex slightly, roundly incised, depressed in the centre. The apex of the mandibles and their inner side to near the middle black. Pronotum transverse, the sides not projecting much. The apical half of the sides of the scutellum are raised and stoutly keeled, its centre with a smooth furrow, which becomes wider towards the apex; the sides of the post-scutellum are more stoutly keeled. Sides of median segment broadly rounded. Second abdominal segment barrel-shape, longer than broad.

The male has the apical half of the clypeus whitish yellow; it is punctured, not striated; all the tibiæ are more broadly yellow, the antennal hook is stout and is fully longer than the last joint; the last abdominal segments are largely marked with black; the punctures on the clypeus do not run into striæ.

The amount of red and yellow on the body varies, as does also the size of the black marks on the basal two abdominal segments. Belongs to the group of *O. tropicus*, Sauss.

ODYNERUS STELLENBOSCHENSIS, sp. nov.

Black; the clypeus, labrum, mandibles, except at the apex, antennal keel, a narrow line along the lower part of the eye incision, post-scutellum and a narrow line on the apices of the basal two abdominal segments, pale yellow; a large rufous line on the upper half of the outer eye orbits, pronotum, an irregular mark, rounded in front, transverse behind, below the tubercles, tegulæ, the median segment, except for a line down the centre, broad at the base, gradually narrowed below, the base of the meta-pleuræ, the first abdominal segment, except for a large hour-glass shaped black mark in the centre, the second segment, except for a large black mark in the centre dilated at the base and greatly dilated at the apex, the other segments, the antennal scape and the under side of the flagellum, ferruginous. Legs ferruginous, the four fore coxæ and the posterior below yellow. Wings fuscous violaceous, the nervures black, the stigma dark testaceous. ♂.

Length 13 mm.

Cape Colony. Stellenbosch.

Front and vertex strongly, closely punctured; the outer orbits smooth and shining on the lower half, strongly keeled on the outer side. Clypeus as broad as long, sparsely minutely punctured, broadly rounded above, the apex roundly, deeply incised in the centre, the projections forming stout teeth. Thorax strongly closely punctured, except on the apex of the meso- and the base of the meta-pleuræ; the pronotum transverse, its sides rounded. Scutellum furrowed down the middle, an obscure rufous spot on either side. Post-scutellum raised, roundly sloped on the apex. Metanotum with a steep slope, deeply furrowed in the centre, the sides broadly rounded. There is an oblique furrow on the basal half of the mesopleuræ; on the sides of the metasternum is a broad, rounded, pale yellow thin plate. First abdominal segment cup-shaped, longer than its width at the apex.

ANTHOPHILA.

GEN. PROSOPIS, Fab.

PROSOPIS RUBRIPLAGIATA, sp. nov.

Black; a large mark on the clypeus, its lower half obliquely narrowed to a point, a large mark on the lower half of the inner orbits, obliquely narrowed above and below, a mark, broader than long and of equal width throughout, between the antennæ, yellow; the sides

of the clypeus broadly below, mandibles, the scape, under side of flagellum, a line on the pronotum, tegulæ, tubercles, the base and sides of first abdominal segment, the sides of the others more or less and the greater part of the ventral surface, rufous. Wings hyaline, the apex in front slightly smoky. Legs rufous. ♀.

Length 8 mm.

Cape Colony. Dunbrody; Grahamstown (Brak Kloof).

Metanotal area with some stout, irregular, curved striæ. Front and vertex closely, regularly, and strongly punctured; antennal area large, raised, rugose and bounded laterally by curved keels. Clypeus strongly, but not so closely, punctured as the front; the cheeks almost smooth. Labrum rufous; the top broadly, roundly raised; the apex depressed, obliquely narrowed, aciculated and with a few scattered punctures. Mandibles black and rufous. Mesonotum closely, strongly and distinctly punctured; the scutellum as strongly, but not so closely punctured. Pleuræ and breast coarsely rugose and thickly covered with white pubescence; the metanotum more closely rugose. Post-scutellum opaque, very sparsely punctured. Abdomen smooth, the apices of the segments with a narrow band of white pubescence. Both the recurrent nervures are interstitial. The male wants the red lateral marks on the clypeus. Both sexes vary in the amount of the rufous colour which they bear; the yellow line on the pronotum may be tinged more or less with rufous. The malar space obsolete.

Prosopis curvicarinata, sp. nov.

Black; the clypeus, face, the yellow continued to the middle of the eyes, the mark becoming obliquely narrowed above, tegulæ, anterior tibiæ in front and the front tarsi, a broad line on the base of the hind tibiæ and their tarsi, lemon-yellow; flagellum of antennæ brownish, black above; wings clear hyaline, the stigma and nervures black. ♂.

Length 3 mm.

Cape Colony. Pearston.

Head, pro- and meso-thorax closely, strongly, and clearly punctured; the metanotum rugose, the metapleuræ more finely and closely punctured; the face and clypeus with the punctures large and distinctly separated; the metanotal area irregularly longitudinally striated. First recurrent nervure received in the apex of the first cubital cellule, the second interstitial. Between the antennæ are two stout keels which are roundly curved above, and

have an indistinct one between them. Flagellum stout, the joints longer than broad except the penultimate.

The front is more strongly punctured than the vertex; there is a narrow keel down its middle. The eyes distinctly converge below; there is no malar space.

Prosopis 5-lineata, sp. nov.

Black, shining, a narrow line on the outer and inner eye orbits and a slightly narrower one down the centre of the clypeus, pale yellow; wings smoky-hyaline, the nervures and stigma black. ♀.

Length 7 mm.

Cape Colony. Stellenbosch.

Face and clypeus distinctly, but not closely punctured, the punctuation on the apex of clypeus closer and stronger. Front strongly keeled; the centre with a bordered keel which bifurcates above. Malar space small. Labrum strongly punctured. Thorax shining; the mesonotum and scutellum smooth; the metanotal area strongly, closely aciculated; on the apex is a large, deep fovea, wide below, gradually narrowed above. Pleuræ thickly covered with longish white pubescence; the tubercles behind bordered by a dense band of white pubescence. The hair on the ventral surface is dense and white. The apical dorsal segments covered with black hair. The pubescence on the tibiæ and tarsi long, dense, and grey. Both the recurrent nervures are received in the second cubital cellule; the first at a greater distance from the base than is the second from the apex. The base of the thorax is rounded above. Third joint of antennæ fully twice the length of the fourth; the joints not very sharply separated.

Gen. COLLETES, Latr.

Colletes? capensis, sp. nov.

Black; the head, thorax, and, to a less extent, the abdomen, densely covered with longish clear white hair, the hair on the scutellums long and more fulvous in tint; the wings clear hyaline, the nervures and stigma black; the basal ventral segment dilated, broadly roundly incised in the centre; apex of mandibles piceous. ♂.

Length 7–8 mm.

Cape Colony. Pearston.

Front and vertex closely rugosely punctured, a keel below the ocelli. Clypeus smooth, more shining, as strongly, but not so closely, punctured as the front. Labrum smooth and shining, furrowed in the middle. Mandibles keeled down the middle and on the sides, the three keels not reaching to the apex. Pro- and

meso-thorax closely and strongly punctured; metanotal area stoutly, irregularly striated round the edges, the centre less strongly than the base and apex. Abdomen closely and rather strongly punctured; the edges of the segments pale; the last broadly rounded.

Head as wide as the mesonotum, the temples obliquely narrowed; the malar space large, as long as the antennal scape, striated; eyes parallel, not converging above or below. The second cubital cellule in front is fully one-fourth longer than the third; the second recurrent nervure is roundly curved outwardly below; the cubitus ends shortly beyond the third transverse cubital nervure.

Unfortunately my dissection of the trophi of this species has not proved a success, and I am not quite certain if the tongue be broad or pointed, but on the whole it agrees better with *Colletes* than with *Andrena* to which it has a great resemblance. The first joint of the labial palpi is thicker than the others; it is as long as the fourth, the middle two being shorter.

Gen. HALICTUS, Latr.

Halictus robertianus, sp. nov.

Black; densely covered with white pubescence, the apex of the clypeus (the yellow in the centre triangularly projecting into the black upper part), the lower part of the antennal scape, the apex of the femora (the anterior more broadly than the others), the tibiæ and tarsi, pale yellow, the tibiæ on the outer side marked broadly with fuscous; the wings clear hyaline, the nervures and stigma pale testaceous; metanotal area closely, irregularly, longitudinally striated, the striæ twisted and intermixed with some thinner transverse ones. ♂.

Length 5 mm.

Cape Colony. Pearston.

Face and upper part of clypeus closely, minutely, distinctly punctured; the yellow apex of the clypeus smooth; front and vertex less distinctly punctured. Basal two-thirds of mandibles pale yellow, the apex piceous. Thorax closely, uniformly, minutely punctured; there is a smooth, narrow, impressed line on the basal half of the mesonotum in the centre. Tegulæ testaceous. Second and third cubital cellules in front almost equal in length.

Allied to *H. albidus*, Lep.

Halictus rubricaudis, sp. nov.

Black, the apical half of the last abdominal segment and the rima rufous; the head, thorax, and ventral surface of abdomen densely

covered with long cinereous pubescence; the base and apex of the second to fourth dorsal abdominal segments with a band of cinereous pile; the wings clear hyaline, the stigma and nervures dark testaceous; the tarsi ferruginous below, cinereous above; the knees and apex of tibiæ rufo-piceous; metanotal area rugosely punctured in the centre, the sides closely, finely reticulated. ♀.

Length nearly 8 mm.

Cape Colony. Pearston.

Face projecting roundly in the centre, finely and closely punctured; the clypeus shining, sparsely punctured on the basal two-thirds. Front and vertex opaque, alutaceous. Mandibles broadly rufous in the middle; they are, as is also the labrum, fringed with long, golden hair, the hair on the hinder edge of the vertex being also tinged with golden. The flagellum of antennæ dark rufous, black above. Mesonotum closely, uniformly, and somewhat strongly punctured, the scutellum as strongly, but not so closely punctured. The apex of the metanotum has a steep slope; its centre above is depressed slightly, the sides broadly rounded on either side of the central depression, the edges being smooth and shining. Pleuræ closely, finely rugose. Abdomen at the base closely and distinctly punctured, the third and following segments only indistinctly punctured; they are not depressed; the anal rima is large and conspicuous; the epipygium has a large tuft of rufous hair on the apex. Tegulæ piceous.

Halictus pearstonensis, sp. nov.

Black, shining; the apex of the first and the greater part of the second, third, and fourth abdominal segments rufous; the knees and tarsi fuscous; wings clear hyaline, the nervures and stigma black. ♂.

Length 5 mm.

Cape Colony. Pearston.

Front, face, sides of clypeus and cheeks densely covered with long, white pubescence; the face closely punctured, the clypeus much more strongly and sparsely punctured; the front and vertex more closely and less strongly punctured than the face. Pro- and mesonotum shining, covered, but not thickly, with white pubescence; the post-scutellum thickly covered with fuscous pubescence; the metanotal area finely, closely rugosely punctured, the punctures running into reticulations on the sides. Pleuræ opaque, alutaceous, obscurely striated. Abdomen smooth and shining; the base, apex, and ventral surface covered sparsely with long, white pubescence.

The hair on the legs is white; on the lower side of the tarsi pale golden.

The apex of the metanotum has an oblique slope; the reddish second and third abdominal segments are almost bare; the sternum thickly covered with long, white hair; the ventral segments are transverse at the apex; the last is broadly, bluntly rounded at the apex, with the sides slightly obliquely narrowed.

Halictus lampronotus, sp. nov.

Black, shining, impunctate except on the metanotal area which is finely and closely punctured; tegulæ piceous behind; under side of flagellum brownish; mandibles piceous towards the apex; wings clear hyaline, the stigma and nervures fuscous, the second and third transverse cubital and the recurrent nervures paler. Apices of the abdominal segments piceous, the anal rima rufous, the end of the segment pale fulvous. ♀.

Length 4 mm.

Cape Colony. Pearston.

Front and vertex closely, microscopically punctured; the face and clypeus very smooth and shining; the face not projecting much in the centre and not clearly separated from the clypeus. Eyes slightly converging above. Abdomen very smooth and shining; the ventral fringe white; the segments not depressed. Hind tarsi piceous. Third cubital cellule in front about one-quarter longer than the second; the third transverse cubital nervure is almost straight below, the upper part roundly curved towards the stigma; the first recurrent nervure is received near the apex of the cellule, clearly separated from the transverse cubital; the second near the base of the apical third of the cellule.

Halictus thestis, sp. nov.

Black, shining, covered with white pubescence; the apex of clypeus pale lemon-yellow; the labrum, knees, and tarsi whitish testaceous; the scape of antennæ and upper side of flagellum black, the rest of flagellum brown; wings clear hyaline, the stigma fuscous, the nervures black. ♂.

Length 4 mm.

Cape Colony. Stellenbosch.

Face and clypeus closely punctured, thickly covered with white pubescence; the face raised in the centre; the front and vertex opaque, granular; sparsely pilose; the outer orbits thickly covered with white hair. Mandibles yellow, their apex piceous. Thorax

closely punctured, the scutellum less and the pleuræ more strongly than the mesonotum. Metanotum opaque, alutaceous, the base finely, irregularly, indistinctly striated. There is a short furrow on either side of the mesonotum near the base. Second cubital cellule distinctly narrowed in front; the first recurrent nervure received near the apex; the second shortly beyond the middle of the cellule. The second abdominal segment is distinctly, the third less distinctly depressed at the base. The eyes are long, converge below and clearly incised on the inner side.

Halictus dispositus, sp. nov.

Black, shining, the hair bright white; flagellum testaceous below towards the apex; wings clear hyaline, highly iridescent, the stigma dark testaceous, the nervures black. ♀.

Length 5 mm.

Cape Colony. Pearston.

Metanotal area closely, distinctly reticulated, the sides more irregularly obliquely striated. Clypeus strongly, deeply, irregularly, but not closely punctured. Face with shallow, scattered punctures; the front and vertex closely minutely punctured; on the upper half of the front is a shining, impressed line, on the lower a fine keel which extends to between the antennæ. Pleuræ opaque, coarsely granular; a deep, oblique furrow below the tubercles. Abdomen shining, impunctate, the apices of the segments pale testaceous; the anal rima blackish, the sides except at the apex distinctly margined, the apex depressed, rounded behind, dark testaceous. Labrum covered with stiff black hairs, which give it a striated look. The third transverse cubital nervure is broadly rounded; the first recurrent nervure is almost interstitial, being received in the extreme apex of the cellule.

Halictus æthiopicus, sp. nov.

Black; the abdominal segments broadly banded with rufo-testaceous; legs bright rufo-testaceous, their tibiæ streaked with yellow; the coxæ, trochanters and base of anterior femora black; mandibles piceous, black at the base; antennæ black, the flagellum testaceous below; wings clear hyaline, highly iridescent, the stigma and nervures pale testaceous, the costa darker; the apical nervures beyond the third transverse cubital nervures almost obsolete. ♀.

Length nearly 6 mm.

Cape Colony. Pearston.

Metanotal area finely closely reticulated. Head and thorax

smooth and shining; the face and clypeus with faint purple tints; the latter fringed with golden hair. Tegulæ piceous. Legs thickly covered with long, white hair. Ventral hair long and white. Anal rima rufo-testaceous like the rest of the segment, smooth, with an impressed line down the centre.

Halictus interstitinervis, sp. nov.

Black; the hair and pubescence dense and white except on the under side of the tarsi where it is bright red; anal rima fuscous in the centre; wings clear hyaline, the stigma fuscous, the nervures black; the first recurrent nervure interstitial. ♀.

Length 6–7 mm.

Cape Colony. Stellenbosch.

Antennæ brownish beneath towards the apex. Clypeus shining, distinctly punctured, the punctures large and clearly separated; the centre of the face raised, minutely punctured; the front and vertex closely and finely punctured. Mandibles shining, black. Meso-notum and scutellum closely, distinctly, finely punctured; the basal half of the former with a distinct, clearly defined furrow in the centre; the post-scutellum thickly covered with griseous hair. Metanotal area irregularly striated to near the apex; the striæ in the middle forming almost reticulations. Pleuræ alutaceous. The second and third cubital cellules in front are almost equal in length; the third transverse cubital nervure roundly curved; the first recurrent nervure interstitial; the second received in the apical fourth of the cellule. Abdomen shining, closely, microscopically punctured; the base of the segments with a band of greyish powdery pubescence; above it is almost without hair; the ventral scopa clear white.

Halictus lippani, sp. nov.

Black, the hind knees and tarsi white, the apical tarsal joints tinged with fulvous; the apex of clypeus broadly pale lemon-yellow; flagellum of antennæ dark brownish beneath; the head in front and pleuræ thickly covered with white pubescence; wings hyaline, the nervures and stigma black. ♂.

Length 7 mm.

Cape Colony. Grahamstown. (Glen Lynden, January.)

Face closely, the clypeus more strongly and sparsely punctured; the front and vertex more closely and rugosely punctured except below the ocelli. Base of mandibles yellow. Pro- and meso-notum closely, strongly punctured; an impressed line on the basal half of the latter; the pleuræ closely rugose. Metanotal area in the centre

coarsely reticulated, the sides obliquely striated; the rest of the segment except behind the area closely rugose. Abdomen closely strongly punctured, the punctuation becoming weaker towards the apex; the third and fourth segments obliquely depressed at the apex; the apices of the last two smooth. The first recurrent nervure is interstitial.

This species is closely related to what I take to be *H. albidus*, Lep.; the two may be separated thus (the males of both only are known):—

Length 7 mm.; antennæ not reaching to tip of thorax, dark coloured below; metanotal area coarsely reticulated in the middle, the sides stoutly obliquely striated; the stigma and nervures black, the first recurrent nervure interstitial; the femora and tibiæ black	*lippani.*
Length 5–6 mm.; antennæ reaching beyond tip of thorax; the flagellum light testaceous below; metanotal area closely reticulated; the stigma and nervures pale; the first recurrent nervure not interstitial; the femora and tibiæ in part yellowish white ..	*albidus*, Lep.

When fresh both species have probably the abdominal segments banded with depressed white pubescence.

Halictus capicola, sp. nov.

Black; the head and thorax thickly covered with long cinereous hair, the depressed bases of the abdominal segments with cinereous pile, the ventral surface covered with long cinereous hair; the anal rima dark piceous-rufous, the sides and apex of the segment being similarly coloured; metanotal area strongly irregularly longitudinally striated, its apex more closely finely and less distinctly striated. Wings hyaline, iridescent, the nervures and stigma black. ♀.

Length 8 mm.

Cape Colony.

Clypeus strongly punctured to shortly beyond the middle, the punctures large and distinctly separated; the apex smooth except for a few elongated punctures. Mesonotum closely punctured and with an impressed line on either side of the middle; the centre of scutellum smooth, the sides sparsely, indistinctly punctured. Abdomen smooth, a transverse, minute furrow on the second and third segments. The apical joints of the tarsi are piceous; the hair on the under side bright rufous.

Gen. ANDRENA, Latr.

Andrena malma, sp. nov.

Black; the head with long white, the thorax with rufo-fulvous pubescence, the hair on the pleuræ and sternum paler than it is on

the mesonotum; the abdominal segments with broad bands of depressed white pubescence; the hair on the legs long, white; the tarsi rufous; wings hyaline, the stigma fuscous, the nervures black. ♀.

Length 10 mm.

Cape Colony. Brak Kloof; Grahamstown.

Front and vertex closely punctured; a stout keel between the antennæ; the face and clypeus more strongly punctured, the punctures becoming larger and more confluent towards the apex of the clypeus; malar space finely, closely striated; labrum smooth and shining, deeply furrowed in the centre. Pro- and meso-thorax closely and strongly punctured, the punctures round; the metanotal area strongly irregularly striated, the striæ running into reticulations; the reticulated central part shorter than on the sides, the smooth part continued to the apex of the segment, becoming gradually narrowed, its apical half depressed, the convex upper part keeled in the middle. Basal abdominal segment covered with long white, slightly tinged with fulvous, hair; the pilose bands extend on to the ventral surface; the segments are closely, minutely punctured; the apical two fuscous at the apex; the last segment thickly covered with stiff black depressed hair which gives it a striated appearance. Hair on legs white; the calcaria rufous.

Male similar; the antennæ stouter, not much longer than in the female; the clypeus smoother at the apex.

The abdominal bands appear to be lead-coloured under the white pubescence. Tegulæ piceous.

Andrena matha, sp. nov.

Black, a narrow white line on the base of the pronotum; legs black, the tarsi, anterior tibiæ in front and the whole of the posterior rufo-testaceous; wings uniformly dark fuscous violaceous, the nervures and stigma black. ♀.

Length 9–10 mm.

Cape Colony. Brak Kloof. Also an old specimen marked "Transvaal."

Head and thorax closely, strongly, uniformly punctured; the metanotum as closely, but not so strongly punctured; its base strongly, but not closely longitudinally striated. The hair on the front of the head is longish, brownish-rufous. Labrum depressed in the middle at the apex, smooth and shining. Apex of clypeus densely fringed with long dark rufous hair. Base of mandibles rufous. The hair on the apex of the tarsi and on the tarsi bright rufous; on the

scopa dark fuscous. Pygidium densely covered with stiff depressed fulvous pubescence, which gives it a striated appearance; the centre is furrowed.

The tegulæ are large, conchiform, piceous or pale on the outer edge; the occiput almost transverse; the metanotum is shorter and has a steeper slope than usual; the abdomen is also shorter than usual compared with the thorax. The insect is broader and stouter than usual.

Gen. NOMIA, Latr.

Nomia dalyana, sp. nov.

Black; the head, thorax, and base of abdomen covered with long cinereous pubescence; the abdominal segments banded with depressed pubescence of the same colour slightly tinged with fulvous; the last segment ferruginous, its sides covered with pale golden pubescence; legs fulvo-rufous, all the coxæ, trochanters, the fore femora above and below, the middle entirely, the hinder broadly above and a large mark on the basal half of the middle tibiæ on the outer side, black; wings hyaline, tinged with fulvous, the apex of both fuscous violaceous; the stigma fulvous, the nervures blackish. ♂ and ♀.

Length 10 mm.

Cape Colony. Grahamstown.

The male hind femora are greatly swollen, broadly rounded above, straight below, with a short, stout, oblique tooth in the middle; the hind tibiæ narrow at the base, becoming gradually wider towards the apex, which, on the lower side, is produced into a bluntly rounded process, more than twice the width of the base of the metatarsus, which is simple, of uniform width, and not longer than the other joints united. Antennæ black, the scape covered with long fulvous hair. Head closely punctured, more strongly, rugosely on the front. Mandibles fulvo-testaceous, black at the apex. Thorax more strongly and not quite so closely punctured as the head; the scutellum slightly depressed in the middle. Metanotal area clearly defined by a keel behind, strongly but not closely striated; the segment behind it closely rugosely punctured. Abdomen closely and strongly punctured, the second segment and, to a less extent, the third depressed at the base; the bands under the pubescence are lead-coloured. Tegulæ piceous.

The female similarly coloured; the hind femora and tibiæ not dilated; the pubescence on the legs denser and longer; the femora not toothed.

Comes near to *N. calida*, West.; the two may be known, *inter alia*, by the different shapes of the hinder legs; in *Dalyana* the hind

femora are straight at the base below; in *calida* roundly, broadly curved to the tooth; in *calida* the tibiæ are more produced at the apex, with the process longer, sharper, it being very much longer compared with the width of the metatarsus; the black colour on femora, too, extends below on the basal half in *calida;* in *dalgana* it does not extend below anywhere.

Gen. CERATINA, Latr.

Ceratina maculiventris, sp. nov.

Dark green, largely marked with blue and coppery-brassy tints; the clypeus, except for two broad, irregular, curved lines in the centre, labrum, cheeks, mandibles, except at the apex, where they are piceous, the greater part of antennal scape, a narrow line on the pronotum, tegulæ, tubercles, scutellum, a curved line behind it, extending to the wings, post-scutellum, and the abdomen, except for some irregular curved blackish lines and marks; the apex of femora, tibiæ, and tarsi, pale bright yellow; wings clear hyaline, the nervures and stigma pallid testaceous. ♀ and ♂.

Length 3 mm.

Cape Colony. Pearston.

Antennal flagellum brownish testaceous, blackish above. Head and thorax closely, minutely punctured and thickly covered with longish white pubescence; the clypeus with some large, separated punctures in the middle, a narrow furrow runs down from the ocelli. There are three narrow furrows on the base of the mesonotum, and, in the middle, outside these, a shorter, wider one. The metanotum is more strongly and distinctly punctured than the rest of the thorax. Abdomen smooth and shining; the black marks on the back vary; on the basal two segments there may be two broad curved lines; on the others black lateral lines; or there may be hardly any black; the apical segments covered with longish soft white hair; the scopa white. Legs thickly covered with long white hair; the hinder tibiæ and the metatarsus may be lined with black on the outer side.

The marks on the clypeus may be absent; there may be a transverse yellow mark on the face above it; the scutellum may be marked with black on the apex and the ventral segments may be marked with black at the sides. Very probably the number and size of the black markings on the body and legs vary. The apical two ventral segments may be largely black. The second and third cubital cellules are narrowed in front; the second is about one-half the length of the third in front; the first and second transverse cubital nervures are roundly curved.

The genus *Ceratina* is probably well represented in South Africa. Mr. Stadelmann (Die Hymenopteren von Ost-Afrikas, p. 3) states that he knows eight species which agree with the description of *C. capensis*, Sm. Col. Bingham informs me that my species is not in the British Museum Collection.

Gen. ALLODAPE, Lep.

Allodape foveiscutis, sp. nov.

Black, smooth, and shining; the clypeus, the curved, raised inner orbits, labrum, an oblique spot on the outer edge of the malar space, mandibles, under side of antennal scape, a broad band, roundly dilated, on the upper side of pronotum and tubercles, bright lemon-yellow; the abdomen, apex of femora broadly, tibiæ and tarsi rufous; the fore femora, on the apical two-thirds below, bright lemon-yellow; wings clear hyaline, the stigma and nervures fuscous. ♂.

Length nearly 5 mm.

Cape Colony. Pearston.

Smooth and shining; the clypeus sparsely, distinctly punctured; the metanotal area aciculated. Tips of mandibles rufous. Front raised; a smooth, shining line in the centre. Pleuræ and sternum densely covered with long, white pubescence; scutellums covered with long pale hair, the rest of the thorax almost bare. The first abdominal segment is marked at the base and near the apex with fuscous; the apical segments are darker coloured, punctured and covered with white hair. Hair on the legs dense, white; on the four hind femora it is long. The second recurrent nervure is received at a greater distance from the apex than is the first from the base of the cellule.

The scutellum is furrowed in the middle; this furrow has oblique sides, the whole forming a large pyriform depression with the narrow end at the base; the post-scutellum has a narrow, clearly defined furrow in the centre.

Characteristics of this species are the black furrowed scutellums.

Allodape melanopus, sp. nov.

Black, the abdomen red; a very irregular T-shaped mark on the clypeus, its sides irregularly indented and the apical part appearing as if it formed a separate line, a large, irregular, transverse mark, narrowed laterally on the scutellum, a large line on the base of pronotum and a mark on the base of mesopleuræ, irregularly tridentate

below, lemon-yellow. Antennal scape rufous below. Legs black, the knees and fore tibiæ rufous. Wings hyaline, the stigma and nervures black. ♀.

Length 5 mm.

Cape Colony. Pearston.

Labrum and tips of mandibles brownish; the former with scattered punctures. Head and thorax smooth and shining; the base of metanotum strongly aciculated; the pleuræ sparsely pilose. Apical segments of abdomen punctured and covered with white pubescence. The hair on the legs whitish, long and dense on the hind tibiæ, on the hind tarsi it is darker coloured. The second cubital cellule in front narrowed, being there not much more than half of its length behind; the second transverse cubital nervure is straight and oblique; the first recurrent nervure is received close to the first transverse cubital, almost touching it; the second is received further from the apex.

Allodape nigrinervis, sp. nov.

Black, smooth and shining, the apex of clypeus shagreened; a large yellow mark down its centre; it is broadly dilated above, the upper edge roundly incised, the narrowed lower part becoming narrowed below, its sides irregular; the apex and the labrum fuscous, the latter with a few large punctures. Wings hyaline, the stigma and nervures black, the first recurrent nervure received at twice the distance from the base, that the second is from the apex. ♀.

Length nearly 5 mm.

Cape Colony. Pearston.

Ocellar region minutely punctured; the frontal furrow acute; flagellum brownish below; there is a row of punctures along the lower inner orbits, inside the keel; metanotal area minutely punctured; tegulæ fuscous, yellow on the outer side; below and slightly in front of tegulæ is a large pale yellow mark, longer than broad, with straight sides. The hair on the legs thick, long, white, darker coloured on the tarsi which are tinged with testaceous; the spurs pale testaceous. As usual the apical abdominal segments are punctured and pilose. Wings highly iridescent. The lower edges of the top part of the clypeal mark are rounded and do not project downwards.

Allodape pringlei, sp. nov.

Black; a large mushroom-shaped mark on the clypeus, dilated below, but not so widely as above, a broad line on the pronotum,

tubercles, a large mark on the scutellum, roundly narrowed laterally and the tubercles, bright lemon-yellow; the knees, tibiæ and tarsi rufous, the fore femora with the apical third lemon-yellow below. Scape of antennæ rufous, the flagellum fuscous below. Wings hyaline, the stigma and nervures dark fuscous. ♀.

Length 5–6 mm.

Cape Colony. Kokstad; Brak Kloof.

Smooth and shining, including the clypeus; labrum strongly punctured; the base of metanotum aciculated, broadly depressed in the middle. Mandibles black. Base and apex of abdomen blackish; the latter with scattered white hairs. Hind tibiæ infuscated in the middle. Both the recurrent nervures are received close to the cubitals.

ALLODAPE FUSCINERVIS, sp. nov.

Black, shining, the abdominal segments narrowly banded with fuscous at the apex, antennal flagellum brownish below; the mark on the clypeus dilated above and below, the central stem with irregular edges; the cross top part transverse above, the sides straight, the lower side slightly dilated at the outer edge, the whole thinner than the central stem; the dilated apex larger, transverse below, laterally extending to the longitudinal facial furrows, the upper part with the yellow suffused into fulvous; wings clear hyaline, the stigma and nervures fuscous; the recurrent nervures received about the same distance from the cubitals; tegulæ piceous. ♀.

Length 5 mm.

Cape Colony. Brak Kloof.

Clypeus closely, minutely and distinctly punctured, most strongly at the apex. Labrum yellowish, with two large punctures on either side. Apex of mandibles broadly piceous. Frontal furrow narrow, distinct. Metanotal area opaque, strongly aciculated. Tubercles pale yellow, fringed above with pale hair. Hair on legs long and silvery white; the apices of tarsi testaceous.

GEN. CROCISA, Jurine.

CROCISA FULVO-HIRTA, sp. nov.

Black; the head, pronotum, pleuræ, base of metanotum and bands, broader than long and extended backwards along the sides, near the apices of the basal four abdominal segments, the bands not reaching to the middle, of pale fulvous, longish pubescence, the temples, centre of mesonotum and metanotum, the lower side of the pleuræ

and the sternum thickly covered with black pubescence; the hair on the legs black; the outer side of the four hinder tibiæ thickly covered with depressed white pubescence, on the apices of the hinder tarsal joints the pubescence is white, on the lower part of the metatarsus soot-coloured; wings fuscous-violaceous, spotted with hyaline in the middle. ♀.

Length 12 mm.

Cape Colony.

Face and clypeus closely, uniformly punctured, the transverse apex of the latter smooth, the front and vertex more strongly punctured, more sparsely round the ocelli. Mesonotum and scutellum closely and distinctly punctured, the former depressed in the centre, the depression wide, deepest in the centre. Scutellum not flat as usual, and distinctly punctured, narrowed slightly towards the apex, which, in the centre, is roundly depressed; the sides tuberculate above; it does not project over the metanotum. The apices of the first and of the fifth and sixth abdominal segments project obliquely at the apex. Mandibles rufous at the base.

This species has not the flat, plate-like, projecting scutellum of the typical species of the genus, but otherwise appears to be a typical *Crocisa*.

Gen. MEGACHILE, Latr.

Megachile robertiana, sp. nov.

Black; the hair on the head, thorax, apex of abdominal segments, and the basal half of the scopa, clear white; the apical half of the scopa bright red; wings clear hyaline, the nervures and stigma black. ♀.

Length 7–8 mm.; breadth 3 mm.

Cape Colony. Pearston; Grahamstown.

Mandibles, except at apex, thickly covered with white hair; behind the apex is a tuft of reddish pubescence; subapical tooth shorter and more broadly rounded than the apical; behind it is a broad, shallow incision. Clypeus strongly and closely punctured, roundly convex; its apex in the centre is slightly roundly incised and depressed, this central part being narrower than the sides. The face is not so strongly nor so closely punctured as the clypeus; the front and vertex are more strongly and quite as closely punctured as the clypeus; the latter is not quite so closely punctured down the centre. Head as wide as the thorax, which is closely and uniformly punctured, except on the metanotum, where the punctuation is weaker and sparser. Legs black; the hair white except on the under side of the tarsi, where it is bright red; the metatarsus not

quite so wide as the apex of the tibiæ, three to four times longer than broad. Tegulæ black.

This species looks very like the Indian *M. hera*.

Megachile prionsa, sp. nov.

Black; closely and strongly punctured, the abdomen less strongly than the thorax; the lower part of front, face and clypeus thickly covered with longish clear white pubescence; the pleuræ and sternum covered with long white, the mesonotum with shorter, darker coloured hair; the abdominal segments fringed with clear white pubescence, white, slightly tinged with fulvous; wings hyaline, the apical half tinged with violaceous; the nervures and stigma black. ♀.

Length 7 mm.

Cape Colony. Brak Kloof.

Base of mandibles shining, distinctly punctured; the rest opaque, finely rugose and irregularly striated, the outer edge keeled; and there is another keel inside this, not reaching to the base; the apex bidentate, the subapical tooth broader, shorter, and more rounded than the apical. Inner orbits keeled, the space between the keel and the eyes irregularly striated. Apex of clypeus transverse, with an irregular edge. Apical slope of metanotum smooth, almost shining, clearly margined above, the sides broadly rounded, slightly depressed in the middle; the basal area stoutly striated, narrow in the middle, widened laterally. The apical slope of abdomen smooth, stoutly keeled all round above; the apical segment with a thick band of pale fulvous pubescence. Some specimens have the wings more violaceous than others; the second recurrent nervure is almost interstitial; tegulæ black. There is a transverse furrow or depression near the base of the second abdominal segment.

Megachile comhala, sp. nov.

Black; the abdomen covered with ferruginous pubescence; the apex of thorax and base of abdomen in both sexes with longer whitish hair; the hair on the head and thorax in female black; the scopa pale fulvous; wings fuscous-violaceous, the nervures and stigma black; the hair on the legs in female blackish, on inner side of tarsi rufous; on the male long, thick and white, rufous on the inner side of tarsi. Mandibles bidentate. ♀.

Length 14 mm.

Cape Colony. Brak Kloof.

Mandibles at the base closely rugose, the middle with longish

punctures and with stout striæ; the apical tooth bluntly rounded; the subapical much shorter, bluntly rounded. Clypeus closely rugose; the apex in the centre slightly broadly incised, the sides broadly rounded. Front with a distinct furrow down the middle. Thorax closely, strongly punctured; the hair on the top short, close and black; on the pleuræ and breast longer, denser and soot-coloured. The female of *imitata*, as named by Smith for me, has the wings much lighter coloured, the mandibles behind the apical two teeth broadly bisinuate, which is not the case with *comhala;* the hair on the face and clypeus white and thick, not black and rather sparse; the hair on the thorax is lighter coloured, and the ventral scopa is paler at the base. I am somewhat doubtful about Mr. Smith's identification of his species; the specimens, however, are rubbed, and that may account for them not agreeing with the description.

The male has the face, clypeus, cheeks and oral region densely covered with long white hair; the front with long soot-coloured, the vertex with shorter black hair; the fore femora, tibiæ and tarsi are rufo-testaceous in front; the fore coxæ armed with a stout longish tooth, which is broader and testaceous at the base; the basal joint of fore tarsi greatly dilated, pale yellow, densely fringed with long clear white hair below; the middle tarsi fringed with longer white hair, the hinder with rufous pubescence on the metatarsus, as in the female. The apex of the last segment is stoutly irregularly serrate; there are four or five teeth on either side, the number and form appear to vary in old examples; the central two are more widely separated than the others. The apical tooth in the male mandibles is longer and sharper pointed than it is in the female; it is probably abraded in the latter. Tegulæ black.

Appears to come close to *M. imitata*, Sm., described in both sexes (Cat. Hym. Ins. Brit. Mus., i., 158), but nothing is said about the apex of the abdomen in the male being denticulate.

Megachile harthula, sp. nov.

Black; the head and thorax densely covered with long whitish hair, that on the mesonotum having a fulvous tinge; the basal four abdominal segments thickly covered with long fulvous pubescence, the fifth with long, stiff black hair, its apex with a band of pale depressed pubescence; the sixth sparsely with long black hair; the ventral surface rufo-fulvous, the segments fringed with pale pubescence; wings hyaline, the apex infuscated, the nervures black; the sixth segment incised in the middle at the apex, the incision becoming gradually wider towards the apex, its base rounded; its

bordering tooth has a short blunt tooth attached to its base on the outer side, outside are four irregular, but stout teeth. ♂.

Length 13 mm.

Transvaal.

Mandibles bidentate, the teeth large; the subapical bluntly rounded, apex of clypeus incised; the third antennal joint twice the length of the second, and distinctly shorter than the fourth. Head and thorax closely, distinctly punctured; the seventh abdominal segment becomes, on the basal half, gradually, roundly narrowed to the middle; the apical half is distinctly narrowed compared with the basal; it is rounded and narrowed at the apex; the sides at the base are depressed; the centre raised to a point behind the middle, the apical portion of this central keel being thus the larger; both have oblique slopes. Fore coxæ with stout, curved spines; the four apical joints of the tarsi are rufous; the hair on the under side of the tarsi fulvous.

Megachile marusa, sp. nov.

Black; the hair on the face, front, and thorax white; the abdominal segments banded with white pubescence; the scopa rufous, white at the base; wings hyaline, the nervures black; tegulæ fuscous. ♀.

Length 8 mm.; breadth nearly 3 mm.

Transvaal.

Mandibles with two bluntly rounded teeth, the second smaller than the first; behind the second tooth they are broadly slightly roundly dilated; their middle deeply, widely grooved, the groove widest at the apex; outside it, on the apical half, is a narrower furrow. Head closely, strongly punctured, less closely in the centre of the clypeus, which has its apex depressed and clearly separated; it is transverse. Thorax closely, strongly punctured; the metanotal area coarsely aciculated. Abdomen closely punctured above, without transverse furrows. The apical joints and the under side of the basal of the fore tarsi are testaceous; the hair on the legs cinereous; the spurs pale testaceous; base of metatarsus two-thirds of the width of the tibiæ; the metatarsus slightly shorter than the other joints united. The mandibles, inside the furrow, bear elongate, large punctures; they are sparsely covered with pale hair.

This species comes close to *M. robertiana*, which may be known from it by the basal half of the mandibles being densely covered with grey pubescence, the apical furrows are much less clearly defined; the apical two teeth more equal in size; the apex of the

clypeus not transverse in the middle and its sides roundly waved; the hair is denser and longer both on the body and legs; and on the under side of the tarsi it is bright red.

Megachile temora, sp. nov.

Black; the hair on the head and thorax white, on the apices of the abdominal segments of a clearer white; the abdominal scopa bright red; the hair on the tarsi and apex of tibiæ red, on the rest of the legs white. Wings hyaline, slightly violaceous at the apex, the stigma and nervures black. ♀.

Length 11 mm.

Cape Colony.

Mandibles with three apical teeth; the apical sharper and longer than the others; behind the third is a short, less distinct one; the punctuation is strong and close; the hair sparse and pale red. Face and clypeus closely and strongly punctured; the apex of the latter transverse, but with an irregular edge; the face more closely, and the front and vertex still more closely punctured. Thorax closely punctured, the punctures forming almost reticulations in places; a smooth, narrow furrow down the centre of the mesonotum; the hair on the pleuræ and metanotum long and dense. Metanotal area coarsely alutaceous; the rest finely closely reticulated. Apex of hind tibiæ smooth, depressed, with a raised broad keel in the centre; metatarsus slightly narrower than the apex of tibiæ, four times longer than it is broad; its outer side at the base with a rounded depression or incision; calcaria longish, curved, testaceous. The hair on the under side of the tarsi is long, thick, and bright red.

This species is not unlike *M. imitata*, Sm., as named for me by the late Mr. Frederick Smith; that has the mandibular teeth broader, especially the apical one at the apex; the punctuation is coarser, and the face is smooth in the centre; the pubescence on the mesonotum has a fulvous tinge, and it wants the central impressed line; the basal half of the scopa is white, the pile on the under side of the tarsi is not bright red, and the apex of the clypeus is straight, not with an irregular edge. In *M. imitata* the apical mandibular tooth is large, broad, bluntly rounded at the apex; the second is small, more oblique, and bluntly rounded; it is followed by two broad, rounded projections.

Megachile sarna, sp. nov.

Black; the head, thorax, apex of abdominal segments, and the base of last abdominal segment broadly densely covered with snow-

white hair; wings clear hyaline, the nervures and stigma black; apex of last abdominal segment roundly, deeply incised, the incision bounded by two longish, stout teeth, and with two much smaller teeth on either side, the outer tooth being smaller than the inner one. ♂.

Length 6–7 mm.

Cape Colony. Stellenbosch.

Mandibles closely punctured, the apex smooth and shining; the apical tooth long, becoming gradually narrowed to the apex, the subapical shorter, broader, and blunter; the base on the under side projects into a blunt, stout tooth. Head closely, rugosely punctured; the clypeus projecting, smooth and shining, the apex with a slight, but distinct incision, forming a broad curve. Pro- and meso-thorax closely and strongly punctured; the metanotum sparsely punctured, the area alutaceous, furrowed down the centre. Abdomen closely punctured, the punctuation becoming distinctly stronger towards the apex, the last segment being coarsely rugose. Fore coxæ with a stout tooth at the base, broad at the base, narrowed at the apex; the base of the tarsal joints testaceous.

Gen. PODALARIUS, Latr. (ANTHOPHORA, Auct.).

Podalarius ruficaudis, sp. nov.

Black; the hair on the vertex, upper part of thorax and of abdomen griseous, tinged with fulvous and tipped with black; on the face and sides of thorax white; the apices of the abdominal segments with paler bands, the penultimate segment and the sides of the last covered with long rufous hair; the hair on the legs white, rufous behind; wings hyaline, slightly tinged with violaceous, the nervures and stigma black. ♀.

Length 12–13 mm.

Transvaal.

Clypeus and labrum closely, rugosely punctured; the former with a keel down the central half. Mandibles entirely black, the base with elongated, irregular punctures; the vertex and front shagreened, the ocellar region smooth and shining; a furrow leads down from the ocelli. The hair on the thorax is long and dense; there is a smooth, bare, shining furrow in the centre of the metanotum. Pygidium bare. Ventral scopa tinged with rufous at the apex. On the end of the penultimate joint of the hind tarsi is a tuft of bright red hair.

The male is similarly haired, except that the bands of paler hair on the apices of the abdominal segments are paler and more

distinctly defined; the clypeus, labrum, a narrow line on the lower part of the face above the clypeus united to a large mark on the inner orbits which is triangularly incised above, a narrow line on the under side of the antennal scape and the basal half of the mandibles, yellow. The ventral segments are testaceous, narrowly yellow on the apex; the apices of the apical three slightly incised.

Allied to *P. coccina*, Kl., and *fallax*, Sm. Col. Bingham informs me that the species is not in the British Museum Collection.

Podalarius pallidicinctus, sp. nov.

Black; the lower part of the face, the part on the sides roundly incised above, clypeus, except for a curved black line along the upper half, the line narrowed above and below; labrum yellow, a black mark on either side of the top, the mandibles, except at the apex, yellow; the apices of the abdominal segments broadly banded with pale yellow. Wings hyaline, the apex slightly infuscated. Head and thorax thickly covered with long white hair; the hair on the top of thorax broadly tipped with black. The hair on the under side of the four posterior tarsi rufous. Scape of antennæ broadly yellow below. Tegulæ pale testaceous. ♂.

Length 10 mm.

Cape Colony. Stellenbosch; Grahamstown?

Clypeus sparsely, the labrum closely punctured; the apex of the latter distinctly roundly projecting. Front and vertex closely, but not strongly punctured; a smooth line between the ocelli. The yellow abdominal bands are thickly covered with long white pubescence; the hair on the base of the segments sparser and darker; anal spines longish, stout. Ventral surface broadly brownish in the middle.

What I take to be the female is in the Collection of the Albany Museum. It has the apices of the abdominal segments pale yellow as in the male, but covered by fulvous instead of white pubescence; the second cubital cellule as in it is distinctly shorter than the third in front; the apex of the clypeus is pale yellow and there is a pale yellow mark on the base of the mandibles; the ventral scopa is white and the sides and apices of the segments are testaceous; the hair on the base of the tarsal basal joint is rufous as in the male. Its length is 12 mm. It was taken in June by Dr. Penther.

Podalarius spilostomus, sp. nov.

Black; the head and thorax densely covered with long cinereous hair, which takes a fulvous hue on the upper parts; the basal four

abdominal segments on the apex broadly banded with depressed pale fulvous pubescence; clypeus black; the sides, apex, and a stripe in the centre, which becomes gradually wider towards the apex, fulvo-testaceous, the labrum similarly coloured except for a black line at the base, this line being dilated at the sides; on the apex of the face, in the centre, is a transverse line, which is dilated upwards in the middle. Legs brownish, the tibiæ and tarsi black in front; the hair dense and cinereous, on the tarsi behind rufous. Wings short, hyaline, the nervures and stigma black. ♀.

Length 10 mm.

Cape Colony.

Front and vertex closely, irregularly punctured, the ocellar region and a broad stripe along the sides of it smooth. Clypeus strongly and closely punctured, except along the central stripe where the punctuation is sparse. Labrum closely and strongly punctured, its apex smooth, black and slightly incised in the centre. Metanotal area aciculated. The basal half of the abdominal segments thickly covered with short, black depressed hair; the penultimate segment with a large triangular spot of black pubescence in the centre; the pygidial area dark brown, minutely, closely punctured. Ventral surface closely punctured, with the apical third of the segments brownish, the extreme apices lead-coloured.

The pubescence on the abdomen is shorter and more depressed than it is in the other African species known to me. The two large black marks on the clypeus are rounded and narrowed at the apex. Tegulæ piceous. Calcaria dark testaceous. The second cubital cellule is much narrowed in front, not half its width behind, being the length of the space bounded by the recurrent and second transverse cubital nervures and not half the length of the third in front; the third is narrower in front than behind, through the third transverse cubital nervure bending obliquely in front towards the base of the cellule.

Col. Bingham informs me that this species is not in the British Museum Collection.

Gen. HABROPODA, Smith.

Habropoda capensis, sp. nov.

Black; a transverse mark, transverse in front, rounded behind, on the apex of the clypeus; the hair on the head and thorax long, dense and cinereous, on the apices of the abdominal segments bright fulvous, as it is also on the under side of the legs; the last joint of the tarsi rufous; anal rima black bare; wings

hyaline, the apex slightly darker, iridescent, the nervures and stigma black. ♀.

Length 17 mm.

Cape Colony. (Brak Kloof); Transvaal.

Face and clypeus closely, strongly punctured; the apex of the clypeus transverse, smooth, slightly raised; the labrum more coarsely punctured and with a large tuft of long pale hair in the centre. Ocellar region smooth and shining, the rest of the vertex and front shagreened. Pro- and meso-thorax closely, strongly punctured; the metanotum coarsely shagreened. The hair on the basal segment of the abdomen is long and white; on the second to fourth depressed, short, brighter and paler on the apices of the segments; on the penultimate segment it is much longer and fulvous. The anal rima coarsely shagreened. The mandibles are black at the base, the apex broadly cream-coloured. The hair on the legs is very long and dense; on the outer side of the hinder tarsi is a shield-shape plate, broad at the base, becoming roundly narrowed towards the apex and covered with depressed fulvous pubescence.

I only know the female of this species. I am not sure but that *Macrocera capensis*, Lep., may be its male. My species is a true *Habropoda*.

PLESIANTHIDIUM, gen. nov.

Similar to *Anthidium*, but with the maxillary palpi 3-jointed and the mandibles unidentate.

This genus is founded on a large species, densely haired on the head, thorax, and abdomen, and having the general form and abdominal structure of *Anthidium*, but sufficiently distinguished from it by the characters noted above. The first recurrent nervure is almost interstitial, the second received distinctly beyond the second transverse cubital. The abdomen wants entirely the yellow markings found on most species of *Anthidium*. The first and third joints of the maxillary palpi are about equal in length; the middle one is as long as both united and thicker than them; the labial palpi are as in *Anthidium*, the trophi being long as in that genus. The mandibles, behind the apical tooth, are straight.

Plesianthidium fulvopilosum, sp. nov.

Black, the clypeus yellow; the upper part of the head and thorax thickly covered with long bright fulvous, their lower parts with long white hair; the upper part of the abdomen with fulvous, the ventral surface with paler pubescence; wings

fuscous-hyaline, suffused with violaceous tints; the nervures and stigma black. ♂.

Length 15–16 mm.

Cape Colony. O'okiep.

Head closely, rugosely punctured. Base of mandibles aciculated, pilose; the central part strongly, but not closely, punctured. Thorax closely, somewhat strongly punctured; the metanotum, if anything, more strongly punctured; the basal area smooth. Abdomen closely, but not so strongly punctured as the thorax; the apices of the segments brownish; the last segment tridentate; the middle tooth large, broad, slightly longer than its width; its apex rounded, projecting roundly, but not much at the sides; the lateral teeth smaller, shorter, broad at the base, narrowed towards the apex, which is rounded. Legs thickly covered with long pale hair; the hair on the tarsi of a brighter fulvous tint.

Gen. ANTHIDIUM, Fab.

Anthidium capense, sp. nov.

Black; the clypeus, an irregular line on the apex of the sixth and the whole of the apical segments yellow; the apices of the basal five abdominal segments whitish-yellow; the front, vertex, and upper part of thorax thickly covered with long reddish-fulvous hair; the hair on the face, clypeus, pleuræ, and abdomen white, the hair on the back of the abdomen with a faint fulvous tinge. Wings hyaline, the nervures and stigma black. ♂.

Length 9–10 mm.; breadth 4 mm.

Cape Colony.

Middle of mandibles with a broad yellow band above. Apex of abdomen with four teeth; the outer slightly shorter and broader than the inner. The tarsi, except at the base, and the anterior tibiæ in front are testaceous; middle femora with a short blunt tooth on the apex. Head and thorax closely and strongly punctured. Apex of scutellum bluntly rounded.

The female has the head and mandibles entirely black; the scopa and the hair on the under side of the tarsi rufous; the apical joints of the tarsi ferruginous. The antennæ with both sexes are entirely black; the basal five bands on the abdomen, in both sexes, are narrow and of uniform width; the last segment, in the female, is entirely black; the calcaria pale. The tooth on the apex of the middle femora is found also in the female. The hind tibiæ narrowed at the base, becoming slightly, gradually wider towards the apex, which is wider than the metatarsus. Tegulæ black.

ON THE STRUCTURE AND AFFINITIES OF THE ENDOTHIODONT REPTILES.

By R. Broom, M.D., B.Sc., C.M.Z.S., Victoria College, Stellenbosch.

(Read September 28, 1904.)

(Plates XII., XIII., XIV.)

In 1868 Huxley (1) described, under the name *Pristerodon McKayi*, an imperfect skull that had been found by Mr. G. McKay at East London. He regarded it as a "lacertilian skull," and no one seems to have doubted the interpretation till Seeley (2) examined the specimen in 1894, and expressed the opinion that the skull is that of an Endothiodont. There is now little doubt that Seeley's view is correct.

In 1876 Owen (3) described and figured in his Catalogue of South African Fossil Reptiles "a cast of the fore part of the skull and corresponding part of the mandible" of a large Anomodont reptile, which he named *Endothiodon bathystoma*. The original is stated to have been found in the Sneewberg Range, and to be in the "Museum of Albany, Cape of Good Hope." In Lydekker's (4) British Museum Catalogue, 1890, the type is stated to have been presented to the British Museum by the "Directors of the Museum at Albany, Cape Colony." There is still in the Albany Museum, Grahamstown, some bones, which are said to have belonged to the same individual as the type snout. The principal of these are the occiput and a few cervical vertebræ.

Owen was struck by the close resemblance of the snout to that of Oudenodon, especially in the absence of teeth from the alveolar borders of both upper and lower jaws. The new form was, however, observed to differ from Oudenodon in having a number of rounded teeth on what was regarded as the "palatal surface of the maxillary

and palatine bones." Similar rounded teeth were found on the mandible. Owen, in this first description of Endothiodon, does not give a very clear idea of the anatomy of the new type.

In 1879, Owen (5) published an important paper on the Endothiodont Reptilia, in which he gives further evidence of the structure of *Endothiodon bathystoma*, and describes a well-preserved snout of a new Endothiodont which he names *Endothiodon uniseries*. He discusses at some length the affinities of the group, and concludes that the Endothiodonts are allied to Oudenodon, but belong to a distinct family of the order Anomodontia. The teeth of the upper jaw he regards as belonging to the palatine bones.

In 1890 Lydekker (4) re-examined the British Museum Endothiodont specimens, and placed them in the family Endothiodontidæ of the sub-order Dicynodontia. Lydekker recognised that the upper jaw teeth belong to the maxillary bone, and thus showed that Endothiodon is even more closely allied to Oudenodon than had been believed by Owen. An imperfect skull which Owen had described under the name *Theriognathus microps* is believed by Lydekker to be that of a young *Endothiodon uniseries*. I am not aware that this opinion has been confirmed by any more recent worker, and though any opinion of this nature expressed by Lydekker must carry great weight, I am inclined to think that Lydekker is mistaken.

In 1892 Seeley (6) described and figured the lower jaw of *Endothiodon bathystoma*, and showed the structure of the teeth. He concludes that "all the characters of the dentition suggest near affinity with the Theriodontia."

In 1895 Seeley (2) further discussed the affinities of the Endothiodonts. He pointed out for the first time that Pristerodon, of Huxley, is really an Endothiodont. He also expressed the opinion that *Endothiodon uniseries* of Owen should be made the type of a new genus which he named Esoterodon. Owen in 1879 had suggested the possibility of *E. uniseries* belonging to a different genus from *Endothiodon bathystoma*, and though Lydekker agrees with Owen in making the one genus include both species, I am of opinion that Seeley's view is the more correct. Seeley described a new genus Cryptocynodon allied to Esoterodon. This is founded on a small imperfect skull which is too imperfectly preserved to reveal much that is new in the structure of the Endothiodont skull. Seeley differs from Owen and Lydekker in failing to recognise any marked Dicynodont characters in the Endothiodont skull, which he considers is much more nearly related to the Theriodont type. He regards the Endothiodonts as forming a distinct sub-order Endothio-

dontia, of the order Therosuchia, one of the two principal orders into which he divides the Anomodontia.

Within the last few years the only papers dealing with the Endothiodonts have been one or two by myself (7, 8, 9, 10, 11), dealing with certain points in the anatomy, and describing a few new forms. As, however, a considerable number of new specimens have been discovered, it is now possible to give a pretty complete account of the structure of the skeleton of the Endothiodonts.

Endothiodon bathystoma, Owen.

About a year ago Mr. J. M. Bain presented to the South African Museum a number of fossil bones collected by his father, Mr. T. Bain, many of which are of great interest. Perhaps the most important specimen is the greater part of a skeleton of *Endothiodon bathystoma*. There are preserved the antorbital portion of the skull, the front half of the lower jaw, the parietal crest, the greater part of the occiput, and two fragments of the arches. Of the vertebræ there are preserved 19 of the presacral series and 4 sacral vertebræ. It is possible that all the vertebræ from the first to the seventeenth inclusive are preserved, but there are three points in the series where there may be a break. Immediately behind the axis, one, or possibly two, vertebræ may be missing. On the other hand it is quite possible all the cervical vertebræ are present. Breaks occur between the fifth and sixth, and between the fifteenth and sixteenth vertebræ, but it is improbable that any vertebræ are missing at these points. Behind the seventeenth vertebra there are evidently a number of vertebræ missing, only two being preserved out of possibly seven. The two may be the twenty-second and the twenty-sixth. The sacrum is composed of four vertebræ, all of which are present and fairly well preserved. Of the shoulder girdle there are only preserved the upper and the lower part of the right scapula, and a fragment of the right precoracoid. The proximal half of the right humerus is preserved. The pelvis is fairly well preserved, both ilia being practically complete, and the upper parts of both pubes and ischia being present. The proximal and distal ends of both femora are preserved with the proximal ends of the tibia and fibula of both sides.

In addition to this very fine specimen there is in the South African Museum the anterior part of the mandible of another individual.

The chief new features that are revealed in the structure of the skull are the great width of the occiput, and the presence of a

large parietal crest. Though the skull is very considerably crushed, it is less crushed than is the type specimen. Only a few of the cranial sutures can be distinctly made out.

The premaxillary bones are almost certainly united as in Dicynodon, and are comparatively narrow. They appear to extend backwards between the nasals on the upper surface of the skull, as Owen believed to be the case in *Esoterodon uniseries*, and as is the case in many other Anomodonts. The tooth-like processes in the front of the beak appear to be formed entirely by the premaxillaries. They are much more feebly developed than the caniniform processes in the larger species of Oudenodon. In front of the processes the edges of the premaxillaries pass upwards and inwards, meeting each other like the letter **V**, and forming a narrower depression which looks forwards and downwards, and which no doubt accommodated the sharp hooked point of the mandible. There is no evidence of any teeth in connection with the premaxillaries.

The maxillary bone is of large size, and forms the greater part of the side of the face. Extending back from the tooth-like process of the premaxillary the maxillary forms a narrow ridge which was probably in life covered with horn. Immediately within the ridge is a rather broad groove to accommodate the horny edge of the mandible. This groove is practically devoid of teeth, but on one side there is seen to be a single tooth about 4 cm. behind the tooth-like process. The specimen is not sufficiently developed to show fully the arrangement of the teeth, and owing to the nature of the matrix further development does not seem advisable. There is, however, evident a row of 9 or 10 large teeth on the inner side of the groove. As the row passes backwards other teeth appear by the side of the main row, and at the back part of the row there are 3 or 4 teeth side by side. At the front of the toothed region in the middle line are two fairly large teeth. Unfortunately it is impossible without sectioning the specimen to decide in which bone these median teeth are implanted. Possibly they are displaced.

The palatine bone of the left side is in part fairly well preserved, and very similar to that in the type specimen. It has no teeth.

Part of the jugal bone is seen on the left side. It forms the whole of the lower margin of the orbit.

The lachrymal bone appears to be unusually small, and the prefrontal is also probably smaller than is usual in Anomodonts, though in the absence of the sutures it is impossible to be sure of the exact size and shape. In the upper and anterior corner of the orbit there is a low bony boss which is probably entirely formed by the prefrontal.

The frontals are broad and probably short. The frontal region is slightly concave from side to side, and probably also somewhat concave in the antero-posterior direction.

At the outer and posterior parts of the frontal region are two very prominent ridges which pass backwards and inwards to form the sides of the parietal crest. These ridges are formed mainly by the post-orbitals, but the most anterior part of each ridge is formed either by the frontal or by the post-frontal. Only a small part of the post-orbital part of the post-orbital bone is preserved, but the greater part of the posterior process is in good condition. This posterior portion forms, as in Anomodonts generally, practically the whole of the inner border of the temporal fossa.

The parietals are no doubt long and narrow bones, but they are almost completely hidden by the post-orbitals. There is probably a large parietal foramen situated about 5 or 6 cm. behind the plane of the post-orbital arch.

Of the occiput there are preserved the centre part showing the large condyle, and the foramen magnum, and the whole of the lower part of the left side including the ex-occipital, the lower part of the squamosal and the quadrate.

The squamosal so far as preserved resembles pretty closely that of Dicynodon and Oudenodon. There are, however, one or two points of difference. As in the Dicynodonts generally the squamosal may be divided into three main parts: the part extending inwards to meet the parietal, the zygomatic portion which passes forwards to meet the jugal, and the descending portion which supports the quadrate. There is reason to believe that beyond the place of union of the zygomatic portion with the main part, the squamosal is continued backwards a considerable distance as a trough-like bony plate. From the centre of radiation of the bone which lies near the point of union of the zygomatic portion, the squamosal in Endothiodon appears to send inwards and downwards a well-developed process to articulate with what is probably either the supra-occipital or the ex-occipital. The state of preservation is not such as to enable one to determine the structure of this portion of the occiput. The shape of the lower part of the squamosal will be better understood by reference to the figure than by description.

The quadrate bone lies as in the Dicynodonts, below and in front of the lower part of the squamosal. Though it is impossible to describe the bone with any degree of certainty owing to the condition of the specimen, it would appear as if the bone was fairly similar in structure to that of Dicynodon and Oudenodon. The upper portion spreads out like a fan and lies against the concave descending

portion of the squamosal. The inner part of the bone is well developed, and probably articulates with the ex-occipital. It also gives articulation to the bone which I regard as the tympanic. The articular surface of the quadrate looks forwards and slightly downwards. It appears to me to be convex from above downwards and concave from within outwards.

The occipital bones are not very satisfactorily preserved, and no sutures can be detected. Though in general the occiput resembles that of Dicynodon there are one or two important differences. The condyle is strikingly different from that of any reptile hitherto described. It is of large size and passes back about 25 mm. from the foramen magnum. Instead of being convex, as in almost all reptiles, it is concave in the centre. At the sides it is fairly flat, while the lower third is distinctly convex. Though no sutures can be made out, it is probable that the lower convex part is formed by the basi-occipital bone and that it articulates with the large lower piece of the atlas. The side parts which appear to articulate with the arch of the atlas are probably formed by the ex-occipitals.

The foramen magnum is of small size and about twice as high as broad. The supra-occipital bone, or at least that portion of the occiput above the foramen magnum, is directed almost vertically upwards.

The lateral part of the ex-occipital is well developed and is fairly similar to that of Dicynodon. Instead, however, of being directed mainly outwards, it passes in Endothiodon almost as much backwards as outwards, so that the posterior point of the ex-occipital is as much behind the condyle as the condyle is behind the foramen magnum. There is apparently a pretty large foramen between the ex-occipital and what is possibly the supra-occipital.

The bone which lies below the ex-occipital, and which I regard as the tympanic, is considerably stouter than in Dicynodon and Oudenodon. Its relations, however, appear to be exactly similar in that it lies between the quadrate and the par-occipital process.

The basi-occipital bone so far as preserved agrees very closely with that in Dicynodon.

There is a small part of the basi-sphenoid preserved which shows that it sent a plate-like process down in front of each par-occipital process exactly as in Dicynodon.

The mandible has lost the posterior halves of both rami, but the anterior part of the jaw is well preserved. The fused dentaries and the united splenials are present in almost perfect condition, and there are also seen portions of the angulars and part of the left sur-angular. A small portion of the left articular is attached to the

left quadrate. In the type specimen the lower jaw as well as the snout is very badly crushed, and the extreme massiveness of the jaws is not readily appreciated. Though the mandible differs considerably from that of either Dicynodon or Oudenodon, it agrees rather more with the former than with the latter. In the tusked Dicynodon the front of the lower jaw is much compressed to allow it to pass between the long tusks, and as is the case in the sabre-toothed tigers, the anterior part of the jaw is greatly deepened. In Oudenodon the front of the jaw is much broader than in Dicynodon and relatively less deep, but otherwise the two closely resemble each other. In Endothiodon the jaw, though essentially similar in structure to that of the other Anomodonts, is different in front from that of either Dicynodon or Oudenodon in being much more powerfully built.

The two dentaries, which are anchylosed, make with one another an angle like the letter **V**. There is little doubt that the jaw in front has ended in a sharp upturned point which fitted into the **V**-shaped depression in the front of the upper jaw. The upper border of each dentary behind the pointed portion has two parallel ridges about 12 mm. apart, and inside of the second ridge are the teeth. There is one main row of teeth which has, especially towards the hinder part, an irregular second row of smaller teeth inside and another imperfect row of small teeth outside. The symphysis of the jaw is mainly formed by the powerful splenials, which are anchylosed together, and apparently also anchylosed to the dentaries. A little behind the symphysis each dentary is separated from the splenial by the angular passing forward between them. Immediately outside of the anterior part of the angular the dentary is very much thickened, forming a very marked tuberosity. It is highly probable that practically the whole of the outer surface dentaries has been covered by a horny sheath.

Though Seeley (6) in his account of the lower jaw says nothing of the structure, it is possible from his figure to obtain some idea of the bones forming the posterior part. In the post-dentary portion he shows that there is a deep excavation on the outer side and figures a suture crossing it from above downwards and backwards. There is little doubt that the bone above the suture is the sur-angular and the lower bone the angular. The depression is somewhat similar to the depression in the jaw of *Oudenodon trigoniceps*. The articular region is described by Seeley as "convex from above downwards, wider above than below, and deeper than wide; it measures 7 cm. deep by 4 cm. wide as preserved, but may have been heart-shaped, with a concavity indenting the superior border. Its lateral

and inferior margin is rounded." If the articular condyle is as thus described Seeley would be right in concluding that its form "indicates a difference from Dicynodontia and all other Anomodontia hitherto described." I am, however, inclined to fancy that much, if not the whole of the articular, is lost from Seeley's specimen, and that the articular region did not differ greatly from that in Oudenodon.

The atlas vertebra is as in the Theriodonts and most probably also the Dicynodonts, composed of an arch above and a well-developed inferior element. Owing to the difficulty of satisfactorily removing the matrix it is impossible to give a full description of this and the other vertebræ, but sufficient is displayed to reveal the principal characters. The two halves of the arch appear to be anchylosed and form a short spine. The lower portion of the arch which articulates with the occipital condyle is strongly developed. The articular surface appears to look forwards and a little inwards and to be slightly concave. The two articular surfaces are about 10 mm. apart. From the region of the articulation there passes backwards and slightly outwards a strong transverse process or rib. There is no indication of the process being an autogenous element, and in the absence of evidence it may perhaps be safer to regard it as simply a transverse process. Whether there may have been a rib beyond the process the evidence does not show, but it seems improbable. The inferior element is somewhat similar in appearance to the intercentra of the Stegocephalians. It has in front an articular surface which appears to be concave in the vertical direction. It has also an articular surface behind for the odontoid process. Above the arch of the atlas is a well-developed pro-atlas. It is formed as in the Theriodonts and Anomodonts of two portions. Each portion has a distinct zygomatic process for articulation with the arch of the atlas.

The axis is moderately large. As in mammals and most reptiles it is composed of a normally constructed vertebra with the centrum of the atlas united with it as the odontoid process. The odontoid process, though evidently firmly united with the body proper of the axis, is probably not completely anchylosed with it, as there is a very distinct groove dividing the two elements. Only the posterior part of the odontoid process is displayed. It has a distinct articular surface for the inferior element of the atlas, and is at the posterior part only a little narrower than the body proper of the axis. The body of the axis has on either side and towards the posterior half of the body two deep furrows which approach but do not meet each other at the middle line below. The body is concave behind. On

the level of the upper border of the body there is developed what is evidently a robust transverse process. There is no trace of a rib, but it seems probable that a small rib has been articulated to the lower side of the transverse process and the outer side of the body. The posterior zygapophyses lie for the most part inside of the pre-zygapophyses of the third cervical vertebra. The axis has a fairly prominent spine, but it is not much developed antero-posteriorly.

Beyond the axis there are preserved three cervical vertebræ which may be the third to the fifth, but it is perhaps more probable that they are the fourth to sixth. The three vertebræ very closely resemble each other, and they also resemble pretty closely the axis apart from the odontoid process. For convenience they will be referred to as the fourth, fifth, and sixth. The body of each vertebra has similar lateral grooves to those seen in the axis. The front half of the under side of the body is moderately flat transversely and forms on each side a small tubercle for the rib. The transverse processes are very well developed and pass directly outwards on a level with the upper border of the body. The total width of each vertebra is a little less than three times the width of the body. The spines are lost and the structure of the zygapophyses is not well shown. The structure of the proximal ends of the ribs of the three vertebræ is fairly well seen. Each rib is double-headed and the two heads are rather widely apart, the one articulating with the lower outer and anterior corner of the centrum, and the other with the under side of the outer part of the transverse process. The portion of the rib between the two articulations makes with the shaft an appearance like the letter **Y**. The shaft is slender.

The next series of vertebræ are probably the seventh to the eighteenth. The first of the series resembles pretty closely the sixth cervical and is probably the seventh cervical. The rest of the vertebræ are probably all dorsals. The seventh cervical is slightly imperfect. It differs from the more anterior cervicals in having the ribs more robust. The shaft of the rib passes backwards, outwards, and downwards; and though the rib is still two-headed, the surface for articulation with the underside of the transverse process is so long that it almost joins the articulation for the centrum.

The vertebra which follows the supposed seventh cervical and which is probably the first dorsal shows the centrum to be slightly different from that of the more anterior vertebræ. The articulation for the head of the rib forms a less marked tubercle owing apparently to the head of the rib articulating in part with the interarticular fibro-cartilage. In the second dorsal the tubercle is less developed than in the first, while in the third dorsal the

tubercle has almost disappeared and no trace of it can be seen in the fourth. As the articular surface disappears from the front of the side of the body, an articulation begins to appear on the posterior part of the side. The third dorsal has as large an articulation on the posterior part of the side of the body as on the anterior. Each of the first three dorsals has well-developed transverse processes. In the third they are shorter than in the other two, and in the more posterior vertebræ they become much shorter. The ribs have large articulations with the undersides of the transverse processes, and it is probable that this articulation is continuous with the articular surface of the body and that the ribs are single-headed. The zygapophyses are situated above the level of the transverse processes and are fairly closely together. The spines of the anterior dorsals are short.

The posterior dorsal vertebræ differ from the anterior in having the bodies narrower, deeper, and longer. The width across the transverse processes in the case of the ninth vertebra is less than twice the width of the body. There is little doubt that all the ribs of the posterior dorsal vertebræ are single-headed. The zygapophyses are even closer together than in the anterior dorsals. On passing backwards the ribs articulate less and less with the bodies, and in the posterior dorsal region the articulations seem to be almost entirely with the transverse processes.

The sacrum is well preserved and fairly well displayed. It appears to have consisted of only four vertebræ, and if a fifth was united to the fourth it is unlikely that it gave any support to the ilium. In general appearance the sacrum is not unlike that of the human subject. The body of the first vertebra is broader than deep, and is somewhat excavated at the sides. The sacral rib is of large size. It articulates with the upper part of the body and with a large part of the side of the arch. On passing outwards it expands backwards, forwards, and upwards, and supports the anterior part of the ilium. Each rib is about as wide as the body of the vertebra. The second sacral vertebra has the body considerably longer than the first. Like the first it has the two sides slightly excavated. The rib is shorter than that of the first, but it expands to a much greater extent upwards, so that the height of the outer expanded portion is almost as great as that of the whole vertebra. It extends from the lower border of the ilium to within a short distance of its upper border. The third and fourth sacral vertebræ are very similar to the second, only somewhat smaller, but the ribs, though they extend about as far upwards, do not expand so far downwards as in the second vertebra. Almost the whole of the expanded upper part of

the ilium is supported by the four sacral vertebræ. There are no caudal vertebræ preserved.

The shoulder girdle is very imperfectly preserved, the only parts remaining being the lower part of the right scapula with part of the precoracoid, and a portion of the top of one of the scapula, probably also the right. So far as preserved the scapula agrees pretty closely with that of Dicynodon and Oudenodon. There is a well-developed expansion in front which articulates with the precoracoid, and there is evidence of there having been a distinct acromion, but whether this was as well developed as in Dicynodon the evidence does not satisfactorily show. On the inner side there is at the lower end, as in the Dicynodont scapula, a deep groove leading down to the precoracoid foramen. The glenoid surface of the scapula is nearly at right angles to the axis of the bone. The precoracoid is well developed but appears to have been relatively smaller than in Oudenodon. The precoracoid foramen on the outer surface opens about 10 mm. below the suture with the scapula. In this it differs from the Dicynodont condition and agrees with the condition in the Therocephalians (*e.g.*, Ictidosuchus). It is interesting to note that the anterior border of the precoracoid does not extend so far in the direction of the precoraco-scapular suture as does the scapula. A similar condition was long ago observed in the small Dicynodont shoulder girdle figured by Owen in his Catalogue.

The humerus, which is represented by the upper half of the right bone, is strikingly Dicynodont. The head of the bone has the same kind of broad articulation as is found in the Monotremes, Dicynodon, and Oudenodon. When viewed from above the proximal end of the bone has a somewhat sigmoid curve owing to the deltoid ridge passing forward and outward and the inner angle of the bone being directed somewhat backwards from the transverse head. The deltoid ridge is of large size and bears similar relations to the head as does the ridge in Dicynodon and Oudenodon. At its lower angle the ridge does not form a downward process as in some species of Oudenodon (*e.g.*, *Oudenodon magnus* [= *Platypodosaurus robustus*]). On the posterior surface of the humerus a well-developed ridge passes down the bone from the articular surface. On the inner edge of the bone, near the level of the lower margin of the deltoid ridge, is a fairly well-developed tricipital ridge. It is thus somewhat lower in position than the corresponding ridge in "Platypodosaurus," and it is less prominent. This ridge has been supposed to be absent in Dicynodon, but though less developed than in Oudenodon, it is quite distinct in at least some species of Dicynodon. Close to the lower border of the tricipital ridge is situated the beginning of the entepicondylar foramen.

The pelvis, which is represented by both ilia and portions of both pubes and ischia, is so far as preserved very like the pelvis of Oudenodon. Both ilia are broken across at the constricted portion, but fortunately practically nothing is lost at the seat of fracture on the left side, and the parts can be fitted together. On the right side the fractured surfaces have been much weathered and the bones badly crushed, so that there is a little doubt as to whether the parts have been correctly joined. The ilium is a large bone which terminates above in a long semi-circular crest. The upper portion is fairly flat, but the first half is somewhat concave owing to the anterior part of the ilium being directed outwards. Almost the whole of the upper portion of the ilium is supported by the four large sacral ribs. Posteriorly the upper portion of the ilium ends in a rather sharp process. The middle portion of the ilium is much constricted, and on the posterior side there is a very deep notch between the upper flat portion and the lower articular portion. The acetabulum is of large size and closed as in mammals. The lower portion of the ilium forms nearly half of it, and the articular surface of the ilium looks downwards, outwards, and backwards. The pubis is only represented by the upper or acetabular portion, but though broken off a short distance below the acetabulum, enough remains to show that there was a distinct though probably not very large ischio-pubic or obturator foramen. There is also evidence of there having been in front a distinct pectineal process. The ischium, like the pubis, is broken off a little distance below the acetabulum. It is a much larger bone than the pubis.

The upper and lower portions of both femora are preserved, but unfortunately all the portions are considerably crushed, and it is thus impossible to give a satisfactory description of the bones. On the whole the femur agrees pretty closely with that of Oudenodon.

The upper ends of both tibiæ and of one fibula are preserved. As in Oudenodon, Lystrosaurus, and "Dicranozygoma," the head of the fibula is larger than the head of the tibia. In Endothiodon, as in Lystrosaurus, it is very much longer. The head of the fibula articulates with the side of the head of the tibia and also gives a fairly large articulation to the femur. The heads of both tibiæ are crushed and imperfectly displayed. They are about as broad as deep. There is a deep groove for the tibialis anticus muscle, as in Pareiasaurus.

The following are some of the principal measurements :—

Snout to back of post-orbital arch	180 mm.
Width of frontal region	111

Width of parietal crest	29 mm.
Width of back of skull	324
Width of mandible at back of dentaries	117
Greatest width of humerus	98
Length of four sacral centra	95
Length of iliac crest	125
Length of ilium	154

Esoterodon uniseries (Owen).

This Endothiodont reptile was described by Owen in 1879 (5) from a snout sent to the British Museum by Mr. T. Bain. Though Owen in his paper does not give any locality for the specimen, in the British Museum Catalogue (1890) Lydekker (4) states that the specimen came "from the Beaufort beds on the flanks of the Nieuwveldt range." The specimen consists of the anterior part of a skull which bears some resemblance to that of *Endothiodon bathystoma*, but differs, among other things, in only having a single row of teeth. Owen described it under the name *Endothiodon uniseries*, and, comparing it with Oudenodon and Dicynodon, concluded that "the cranial characters are Anomodont." The row of teeth Owen appears to have regarded as belonging to the palatine bone, and the real palatine bone he looked upon as the pterygoid. Lydekker pointed out Owen's error, and gave what is no doubt the correct interpretation of the bones.

Seeley in 1895 (2) regarded the fossil as the type of a new genus, and though there is no doubt that it is closely allied to Endothiodon, I agree with Seeley in placing it in a distinct genus.

In 1900 I published a restoration of the palate, and showed the structure and relations of the vomer.

With the exception of the type specimen no other remains have hitherto been known. In the collection of fossils obtained by Mr. T. Bain, and recently presented to the South African Museum by his son, Mr. J. M. Bain, there are two specimens which almost certainly belong to this form. The first of these is the anterior portion of the left mandible. It not only belongs to this species, but it is in the highest degree probable that it is the mandible of the same individual. Most likely Mr. T. Bain found the jaw at the same time as the snout, and when sending the snout to the British Museum apparently omitted to send the jaw—possibly thinking the snout was all that was required to determine the form. The second specimen is the crushed occiput and posterior part of the base of the skull. This is also almost certainly a part of the skull of *Esoterodon*

uniseries, and most likely also belonging to the same individual as the type.

The specimen which represents the back portion of the skull, on the whole, bears a fairly close resemblance to the corresponding portion of the skull of Dicynodon.

The occiput is fairly well preserved, though somewhat crushed. The occipital condyle is like that of *Endothiodon bathystoma*, excavated in the centre. When viewed from behind it is kidney-shaped, and about twice as broad as deep. The under side is flattened by the articular surface passing in below the condyle for a considerable distance. The posterior surface is, except for the deep central excavation, moderately flat. The upper and outer corners are rounded, and the middle portion of the upper side passes backwards as a distinct though small ridge. At the outer side of the base of the condyle is a large foramen as in Dicynodon. Immediately above the foramen is a little rough transverse tubercle for the attachment of some muscle. The foramen magnum is a little higher than broad, and is narrower above than below. At either side of the foramen there is a well-developed rounded tubercle, similarly situated to that in the occiput of *Ptychosiagum orientale*. The sutures cannot be made out, and the limits of the ex-occipital are therefore uncertain. The portion of occiput above the foramen magnum slopes forward. In the specimen much of the slope is due to crushing, but it is probable that even in the uncrushed condition the slope is considerable. The ex-occipital has a well-developed external process for the support of the squamosal, as in Anomodonts generally. The downward processes of the basi-occipital are flatter than in the Dicynodonts, but this may be due in part to crushing. In front they are overlapped by the basisphenoid, as in Dicynodon and Oudenodon. In the middle of the basisphenoid there is a deep pit, but whether it ends blindly or leads into a foramen is not revealed in the specimen. On either side of this median pit is a foramen which is probably the carotic foramen. Outside of this and a little in front is a larger foramen. This region of the Anomodont skull is the only region of which the anatomy is still unknown, and as I expect shortly to be in a position to give a detailed account of the sphenoid region, it will perhaps be better to avoid speculation on one or two points, which may possibly be cleared up by one or two specimens which are being sectioned. The back part of the pterygoids is fairly well preserved. It is chiefly noteworthy from the formation by the united pterygoids behind the oval median pterygoid pit of a prominent but very blunt keel.

The lower jaw is represented by the greater part of the left dentary

and splenial, and a small part of the angular and sur-angular. There is a marked general resemblance between this jaw and that of *Endothiodon bathystoma*, but the present jaw is of much lighter build. The dentary has no doubt been anchylosed to that of the other side, and the jaw has ended in front in a sharp upwardly directed process. The upper border of the dentary as preserved shows that portion which met the maxillary. Externally it has a sharp ridge which was probably covered by horn in the living animal. Within this ridge is a groove followed by another ridge. The two ridges are 10 mm. apart. To the inner side of the inner ridge lies the row of teeth. In the specimen the roots of only five are preserved, but there appear to have been at least ten and possibly eleven teeth in the row originally. The last, however, is rudimentary, and the second last small. Owen considers there are nine in the upper jaw. The lower part of the symphysis, and possibly more than half, is formed by the well-developed splenial. The splenial also forms about two-thirds of the inner surface of the portion of the jaw between the symphysis and the lateral fenestra. The anterior portion of the angular fits in between the splenial and the dentary as in *Endothiodon bathystoma*. The anterior part of the sur-angular articulates with the dentary above the lateral fenestra.

The following are the principal measurements :—

Depth of jaw in posterior molar region	60 mm.
Length of molar series (as preserved)	67
Width of occipital condyle	37
Depth of occipital condyle (in middle)	17
Width between ex-occipitals	128

Cryptocynodon simus, Seeley.

This genus, which is closely allied to Esoterodon, is only known by the type specimen which was discovered by Seeley at Molteno Pass, in the Nieuwveldt range. Unfortunately the type specimen consists of only the preorbital portion of the skull, and that in a bad state of preservation. It shows the presence of a single row of simple molars as in Esoterodon, with the addition of a small canine in front of and to the outer side of the row of molars. The arrangement of the palate is very similar to that in Esoterodon, the vomer uniting with the posterior median process of the premaxilla as in that genus, and the suggestion might be made that possibly this is a very young specimen of *Esoterodon uniseries*, the small canine being

lost in later life. Owing to the very imperfect condition of the type specimen it is impossible to settle the point beyond doubt. In the meantime it will perhaps be safest to regard it as a distinct form.

A restoration of the palate is given in fig. 19, pl. xiii.

Prodicynodon pearstonensis, Broom.

This interesting type, which is unfortunately known only by the front half of the skull, and that in a rather imperfect condition, was recently described by me (9) in Records of the Albany Museum. It was found at Pearston, Cape Colony, in the Lower Karroo beds. In general appearance the skull resembles considerably that of Dicynodon, but it differs, among other things, in having a few molar teeth arranged in two rows.

The premaxillary portion of the beak is much broader than is usual in Dicynodon, and also flatter. On the upper surface of the snout only the impressions of the bones remain, and it is a little difficult to be certain about the sutures. The premaxillary certainly passes backwards on the upper side of the snout a short distance, but how far cannot be decided with absolute certainty. In the figure I previously gave of the upper side of the specimen I figured the premaxillaries as passing back between the nasals as far as the front of the frontals. I am now inclined to think that the posterior half of the portion of the snout in front of the frontals is really made up of the nasal bones, and that what I believed to be a suture between the nasal and premaxilla is the impression of a groove on the under surface of the nasal produced by a blood-vessel or nerve. If this latter be the correct view the nasal, instead of being a small element, would be a fair-sized bone. The inter-orbital portion of the skull is much narrower than is usual in Anomodonts. The pterygoids and palatines, so far as preserved, are very similar to those bones in Dicynodon and Oudenodon. The lower jaw is not unlike that of some of the smaller species of Oudenodon, especially *O. trigoniceps*. The dentary has a well-marked longitudinal ridge above the fenestra. The angular fits in between the dentary and the splenial in the same way as in Endothiodon. The canine tooth is round and is relatively smaller than in most Dicynodons, and it is directed well forwards, as in those specimens which are believed to be females. The molar teeth are few in number, arranged in two or possibly three rows, and are not serrated.

In fig. 22, pl. xiii., is shown a restoration of the side view, and in fig. 21, pl. xiii., a restoration of the palate.

Opisthoctenodon agilis, Broom.

This small Endothiodont which, like the previous one, was found at Pearston, and in the same stratum, is represented by a fairly well preserved skull, clavicle, interclavicle, sternum, humerus, radius, and ulna of both sides, carpus and some phalanges of the right manus and portions of the left.

The skull is very like that of a small Oudenodon, and, apart from the presence of molar teeth, I am not aware of any cranial character that would distinguish the two genera. The skull has been already figured in upper view (9). If this figure be compared with the figures of *Kistecephalus arctatus* given by Owen, it will be seen that the resemblance is sufficiently close to make it possible that Owen's species may belong to Opisthoctenodon. Lydekker (4) expresses doubt as to its being a Kistecephalus. One of the specimens (47088) at least most probably belongs to this genus.

The teeth are confined to the maxillary and dentary bones. There appear to be five mature teeth, and there are very clear evidences of replacing teeth developing to the inner sides of the mature ones. Those teeth which are well preserved are seen to have a smooth anterior edge and a deeply serrated posterior border, there being seven denticulations on the only perfect tooth.

The lower jaw is unusually flat and broad in front.

The clavicle is long and slender and very mammal-like. It is curved almost exactly as in man.

The interclavicle is a small, flat, shield-like plate, of which the anterior border is moderately straight and the posterior border rounded.

The sternum is an irregular, rounded flat plate, which is considerably broader in front than behind. It differs greatly in appearance from the interclavicle in that while the latter is formed of dense bone, the sternum has been either cartilage or ossified cartilage or very spongy bone.

The humerus is typically Dicynodont. The large deltoid ridge extends over more than half of the bone. At its lower margin is situated the entepicondylar foramen.

The radius and ulna are not very well preserved, but both bones are fairly similar to those of Oudenodon. The ulna has the olecranon process considerably less developed than in *Oudenodon trigoniceps*.

The carpus I have already described elsewhere. It consists as in Oudenodon, Theriodesmus, and most primitive reptiles, of four elements in the proximal row, viz., radiale, intermedium, ulnare, and pisiform, of two centralia, and of a distal row of carpalia. In

Oudenodon there are apparently five carpalia, in Opisthoctenodon there is evidence of only four. To the radial side of the first digit there is evidently a prepollex. It consists of a distal element lying by the side of the first metacarpal, and with a broad distal end. A small element which appears to support the metacarpal-like element articulates with the radiale and first carpale apparently. A third element lies to the radial side of the more proximal of the prepollex elements. This third element, however, may have nothing to do with the carpus. In the specimen the carpus is crushed into the base of the skull, and owing to the small size of the specimen, and the impossibility of doing much in the way of development, it is difficult to determine whether this third bone belongs to the carpus or is part of the crushed skull. I have figured it as it occurs.

The metacarpals and phalanges are well developed and much more slender than in Oudenodon. The fifth digit is not preserved. There is a small portion of the fifth metacarpal, but whether the portion is the remains of a well-formed digit or the whole of an imperfect one the evidence does not show.

Opisthoctenodon brachyops, n. sp.

This new species is founded on a small skull which has for very many years been in the collection of the South African Museum. It is believed to have come from the Beaufort West District, but the exact locality is uncertain.

Though the specimen is badly weathered it is possible to make out most of the characters. The orbits are fairly round, and look more outwards than upwards. The post-orbital arches, though slender, are more robust than in *O. agilis*. The parietal region is considerably broader than the frontal, and is moderately flat. There is a large pineal foramen and a distinct pre-parietal bone. The post-orbital bone forms almost the whole of the inner wall of the temporal fossa. Posteriorly it meets the squamosal. The posterior zygomatic portion of the squamosal is flat and directed outwards. The anterior part of the squamosal extends forward to under the orbit, but does not meet the maxilla. The jugal is well developed. The maxilla is a strongly developed bone. In front of the lower corner of the orbit is a distinct depression in the bone. The caniniform process is situated almost immediately in front of the plane of the orbit, and is very strong.

The mandible is not well preserved, but in general structure it agrees with Oudenodon. There are apparently four developed teeth with replacing teeth developing on the inner side. There is a distinct socket for at least some of the teeth.

Pristerodon mackayi, Huxley.

Pristerodon is closely allied to Opisthoctenodon, but differs in having two well-developed tusks. The only known specimens have been found at East London in beds of probably similar age to those of Pearston and Beaufort West. In Huxley's type, which is now in the British Museum, there is no evidence of tusks, but this is probably due to the imperfection of the specimen. In a specimen sent many years ago to the South African Museum by Mr. G. McKay the tusks are very distinct. In other respects the South African Museum specimen agrees closely with Huxley's type. The whole skull is more strongly built than in Opisthoctenodon. In the middle line of the snout is a prominent median ridge, and there is a parallel ridge above each nostril as in Esoterodon. The mandible is broader and shorter than in Opisthoctenodon, and turns up much more abruptly in front. At the back part of the dentary is a very strong longitudinal ridge, which passes directly outwards. There are considerably more teeth in the jaw of Pristerodon than in Opisthoctenodon. In the South African Museum specimen there are at least six in a row.

Chelyoposaurus williamsi, Broom.

The type of this species was discovered in a block of sandstone in the Premier Diamond Mine at Kimberley by Mr. Gardner Williams, after whom the specimen has been named. A preliminary description was published in the Records of the Albany Museum (9).

The specimen is represented by most of the presacral vertebræ, many ribs, the right arm, the left femur, and a small portion of the skull. Probably only the atlas is missing among the presacral vertebræ, and if this be so then the full number would be twenty-six. The vertebræ being split through are not very well preserved, but their relative sizes and some other points are seen in the figure given. The ribs are slender and, so far as can be seen, all single headed. The arm is not well preserved, and does not show any features not better seen in other Anomodonts.

The thigh bone is very like that of Oudenodon, having a broad upper end and a narrow middle portion.

The skull fragment consists of most of the left squamosal and jugal bones, a considerable portion of the maxilla, and most of the back part of the mandible. The bones are very like those of Oudenodon, but the specimen is removed from that genus by the presence of a small maxillary tooth. The evidence does not show if there have been more, but it is probable. The tooth is moderately flat,

and has no serrations. It would thus seem that Chelyoposaurus bears a similar relation to Prodicynodon that Opisthoctenodon does to Pristerodon.

Affinities of the Endothiodonts.

It will be observed that while the various Endothiodonts have many characters in common, they can be divided into two groups, the members of which are much more closely related to each other than to the members of the other group. Thus it is manifest that Esoterodon is closely related to Endothiodon and Cryptocynodon, and that Pristerodon is a near ally of Opisthoctenodon. Prodicynodon, though less specialised than the other genera, comes nearer to Pristerodon than to Cryptocynodon.

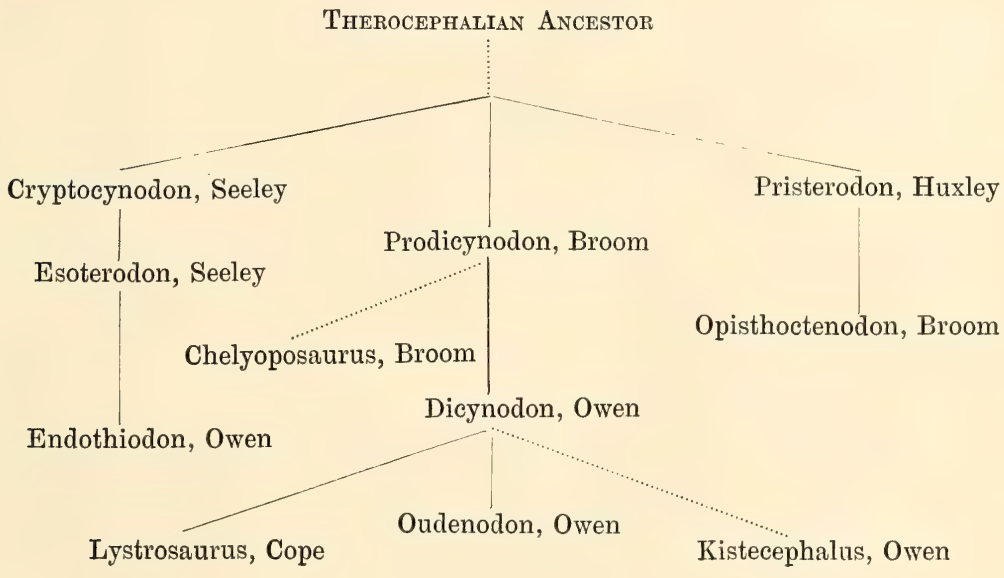
We may imagine the common ancestor of the Endothiodonts to have been a form somewhat intermediate between Cryptocynodon and Prodicynodon, with well-developed canines and with a single row of molars serrated in front and behind. By one line of descent there arose Endothiodon, the intermediate stages being Crytocynodon and Esoterodon. A second line gave rise to Pristerodon and Opisthoctenodon, where the molars are only serrate behind. In the third line the molars became degenerate as in Prodicynodon, and finally lost as in Dicynodon and Oudenodon. Though there is great probability that Dicynodon is descended from Prodicynodon, or a closely allied form, there is considerable doubt as to whether Oudenodon is descended from Dicynodon by the loss of the tusk. The tuskless Endothiodonts, such as Opisthoctenodon, resemble Oudenodon much more closely in general characters than does Dicynodon, but it may be that the loss of the tusk in Opisthoctenodon and Oudenodon has brought about a similar development in the two genera. In the meantime we may regard Oudenodon as bearing the same relations to Dicynodon that Opisthoctenodon does to Pristerodon.

The discovery of the small Endothiodonts has pretty well bridged over the gap between Endothiodon and Oudenodon, and the question might well arise, are we justified in putting Endothiodon in a different family from Oudenodon? Had Dicynodon been a terminal type it would have been convenient to have put it in the same family as the Endothiodonts, but no sooner would it appear were the molars lost than a large number of molar-less forms arose—Lystrosaurus, Kistecephalus, Gordonia, Geikia, and probably one or two others. It therefore seems advisable to place those forms which apparently have sprung from Dicynodon or a closely allied form in one family—

the Dicynodontidæ, and the other Anomodonts, which have molars, in a separate family—the Endothiodontidæ.

With regard to the origin of the Endothiodonts little is known. There is no doubt that there is some affinity between the Anomodonts and the Theriodonts, and though neither can be descended from the other, both doubtless had a common ancestor. There is strong probability that this common ancestor was one of the Therocephalians, but at present unknown. The cranial characters are strikingly similar in the Anomodonts and Therocephalians, and the other skeletal characters also point to a close relationship. When a Therocephalian is discovered which shows a degeneration of the incisor teeth we shall probably have a form allied to the ancestor of the Anomodonts.

The known Endothiodonts may be arranged phylogenetically thus :—



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(4) R. Lydekker. "Catalogue of the Fossil Reptilia and Amphibia in the British Museum," pt. iv., 1890.

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Ac. Acromion; Ang. Angular; B.O. Basi-occipital; B.S. Basisphenoid; c^1 and c^2, centralia 1 and 2; Civ–Cvii, Cervical vertebræ iv and vii; C.Ax. Centrum of Axis; Cl. Clavicle; Co. Coracoid; D. Dentary; Di, Dx, Dxi, Dorsal vertebræ 1, 10, and 11; Ent. For. Entepicondylar foramen; E.O. Ex-occipital; F.M. Foramen Magnum; G.C. Glenoid cavity; i. Intermedium; I. Cl. Interclavicle; Il. Ilium; Is. Ischium; L. At. Lower piece of Atlas; Mx. Maxilla; O.P. Odontoid process; Pa. Parietal; P. At. Pro-atlas; P. Co. Precoracoid; P.F. Pineal foramen; pi. pisiform; Pmx. Premaxilla; P.O. Post-orbital: P. Pa. Preparietal; Pt. Pterygoid; Pu. Pubis; Qu. Quadrate; R. Radius; r. radiale; S.A. Sur-angular; Sc. Scapula; Sp. Splenial; Sp. Ax. Spine of Axis; Sq. Squamosal; St. Sternum; T. At. Transverse process of Atlas; T. Ax. Transverse process of Axis; Ty. Tympanic; U. Ulna; u. ulnare; Vo. Vomer; x. and y. bones of prepollex; z. doubtful element probably not belonging to carpus.

Plate XII.

Fig.

1. Side view of skull of *Endothiodon bathystoma*, × ·37.
2. Upper ,, ,, ,, ,, × ·37.
3. Under view of mandible of *Endothiodon bathystoma*, × ·37.
4. Occiput of *Endothiodon bathystoma*, × ·37.
5. Upper view of vertebræ of *Endothiodon bathystoma*, × ·22.
6. Under ,, ,, ,, ,, × ·22.
7. Front view of atlas and pro-atlas of *Endothiodon bathystoma*, × ·22.
8. Side view of right shoulder girdle of ,, ,, × ·22.
9. Inner ,, ,, ,, ,, ,, ,, × ·22.
10. Front view of right humerus of ,, ,, × ·22.
11. Side view of pelvis of *Endothiodon bathystoma*, × ·22.
12. Upper ,, ,, and sacrum of *Endothiodon bathystoma*, × ·22.
13. Under ,, ,, ,, ,, ,, ,, × ·22.
14. Front view of right femur of ,, ,, × ·22.

Plate XIII.

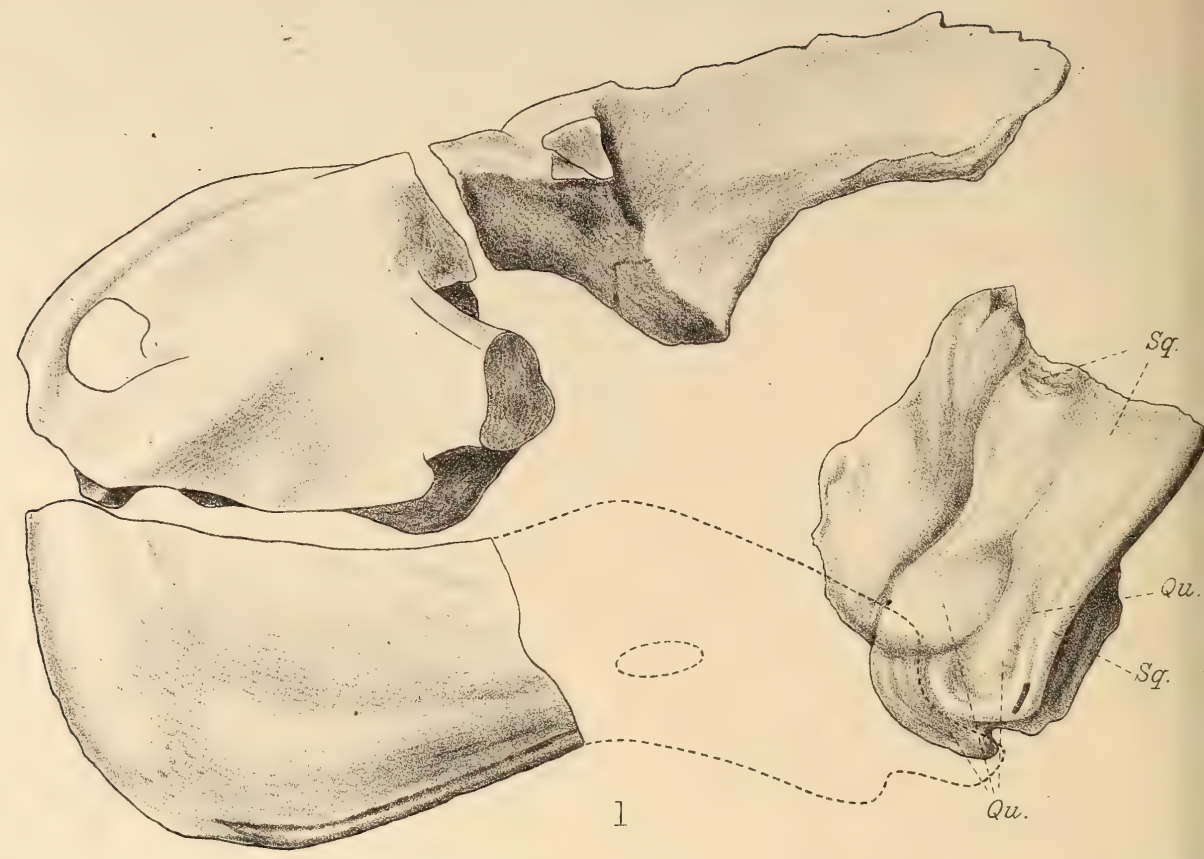
15. Side view of skull of *Esoterodon uniseries*, × ·42.
16. Underside ,, ,, ,, ,, (pal. after Owen) × ·33.
17. Occiput of *Esoterodon uniseries*, × ·54
18. Portion of mandible of *Esoterodon uniseries*, × ·23.

Fig.

19. Restoration of palate of Cryptocynodon, × ·6.
20. ,, ,, Endothiodon, × ·23.
21. ,, ,, Prodicynodon. Nat. size.
22. ,, skull of *Prodicynodon pearstonensis*. Nat. size.
23. Skull of *Opisthoctenodon brachyops*, from above, × ·82.
24. ,, ,, ,, side view, × ·82.
25. ,, ,, *agilis* (restored slightly). Nat. size.
26. Clavicle, inter clavicle, and sternum of *Opisthoctenodon agilis*, × 1·13.
27. Left humerus of *Opisthoctenodon agilis*, × 1·13.
28. Left forearm and manus of *Opisthoctenodon agilis*, × 1·13.
29. Right manus of *Opisthoctenodon agilis*, × 1·13.
30. Molar tooth of ,, × 5
31. Skeleton of *Chelyoposaurus williamsi*, × ·54.
32. Restoration of skull of *Pristerodon mackayi*. Nat. size.

Plate XIV.

33. Restoration of skeleton of *Endothiodon bathystoma*. Reduced.



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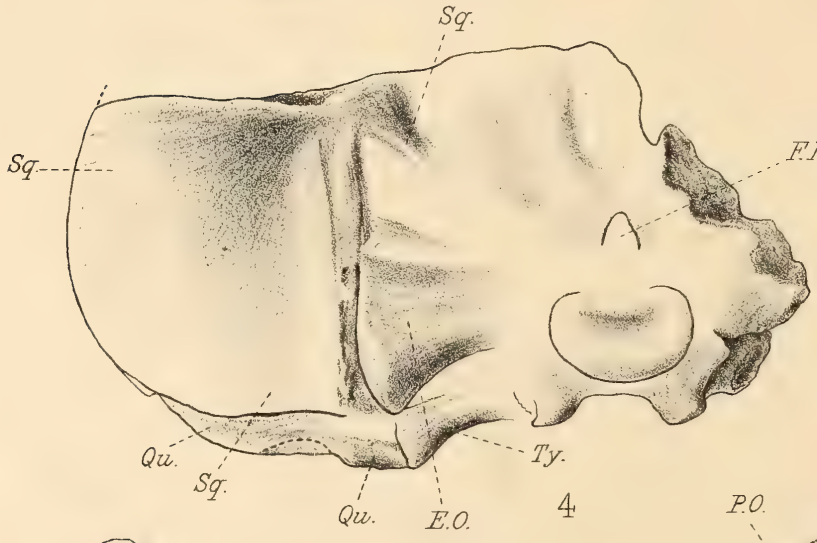

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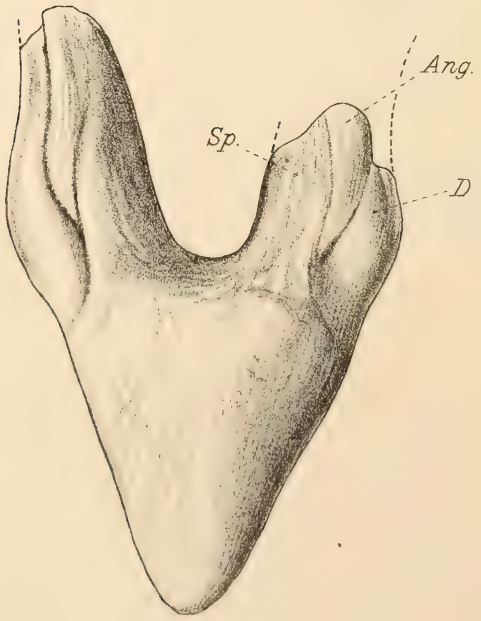

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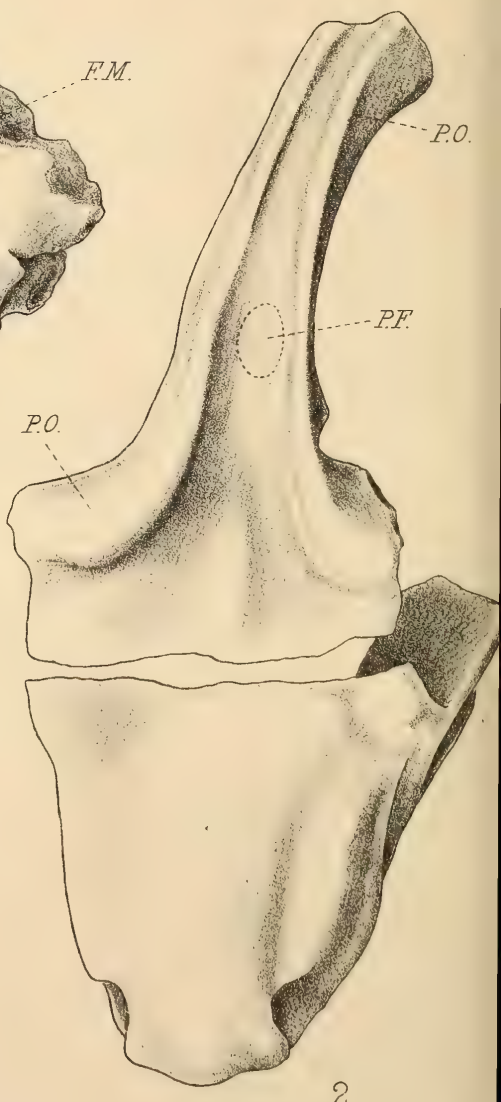

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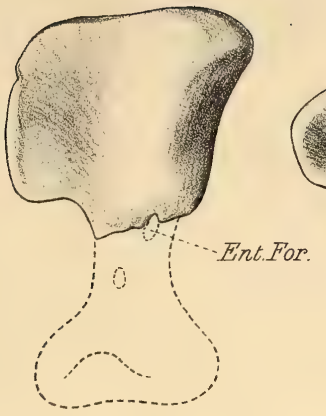
R. Broom del

ENDOTHIODON BATHYSTOMA, *Owen.*



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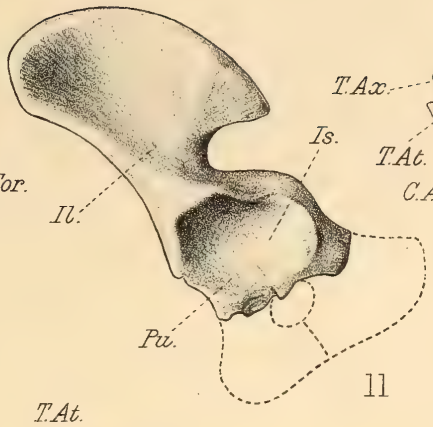

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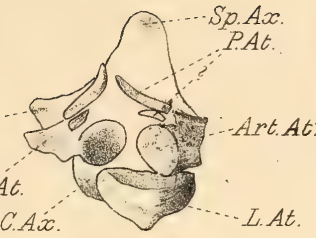

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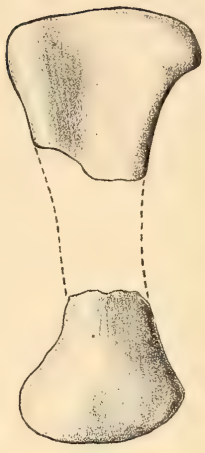

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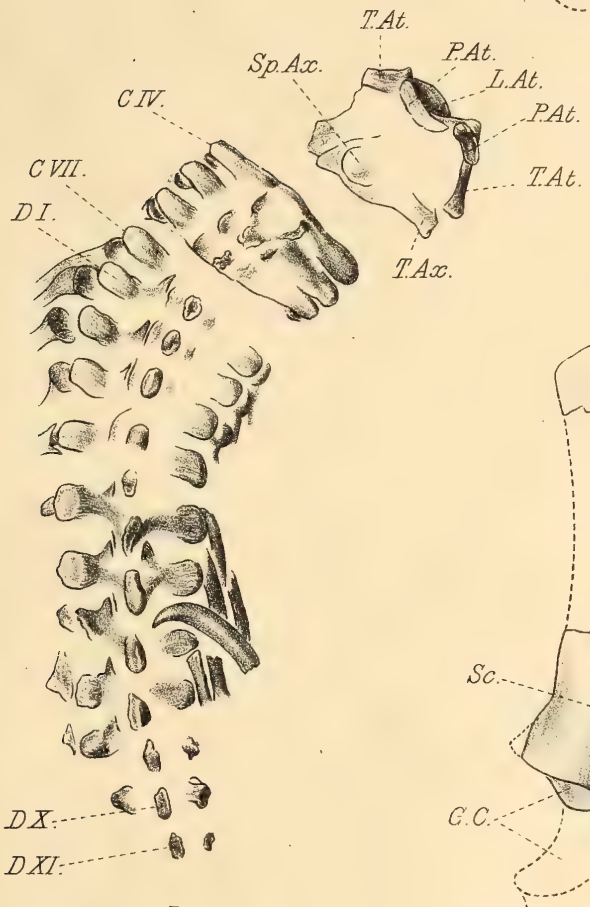

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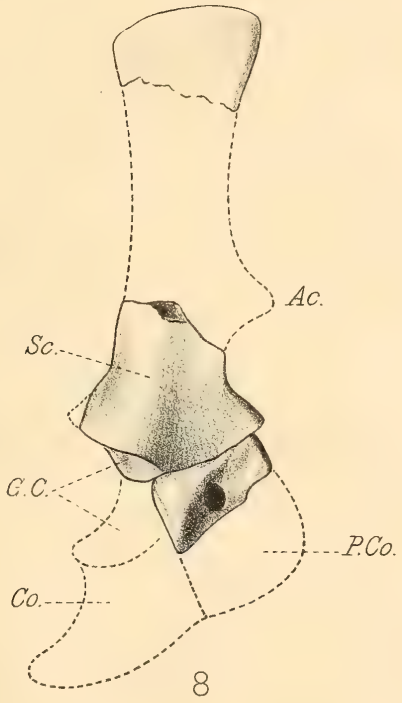

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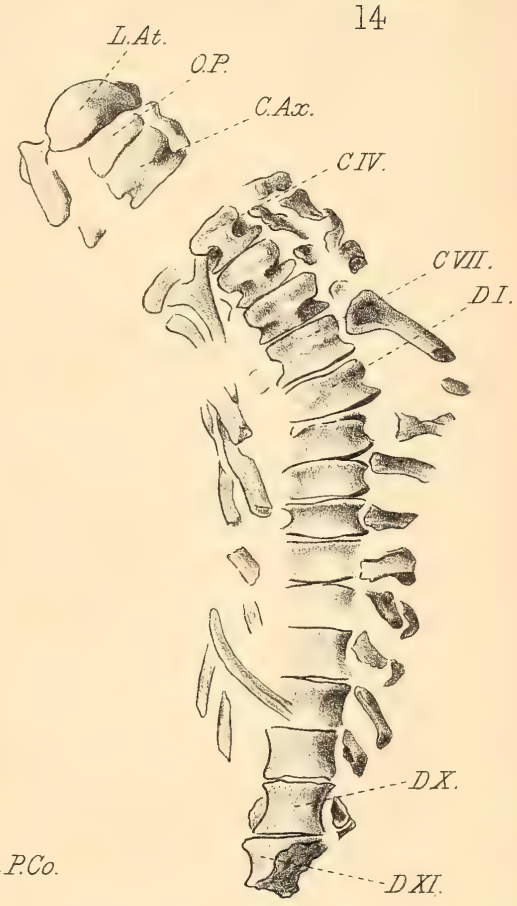

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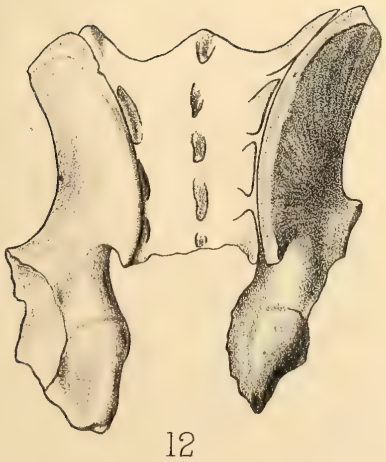

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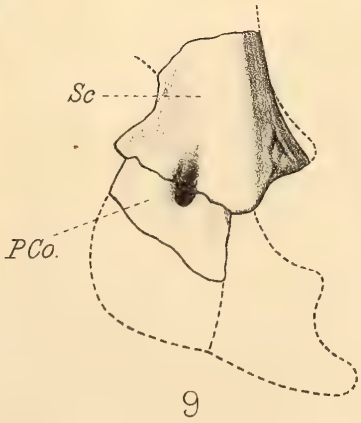

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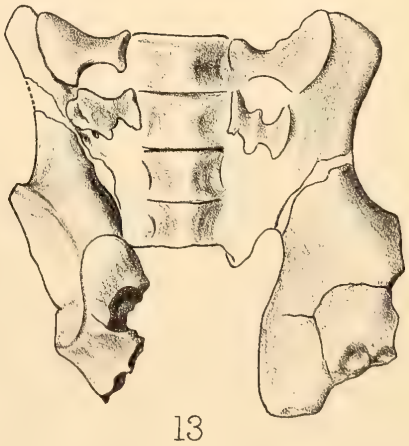

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West, Newman lith. London.

ENDOTHIODON BATHYSTOMA, *Owen*.

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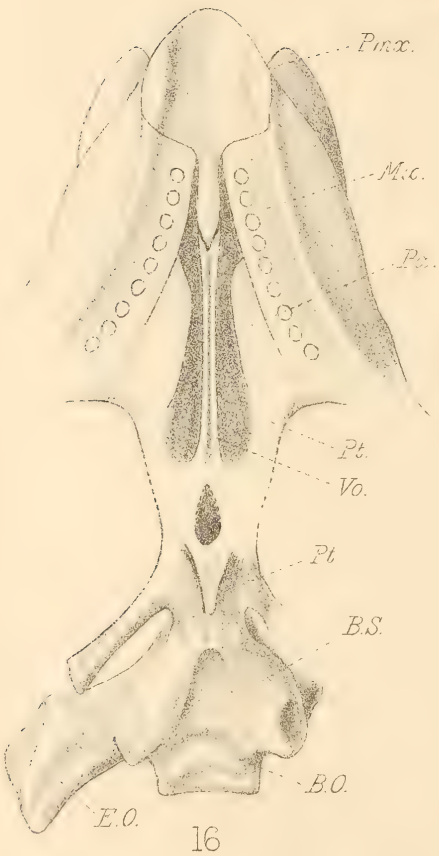

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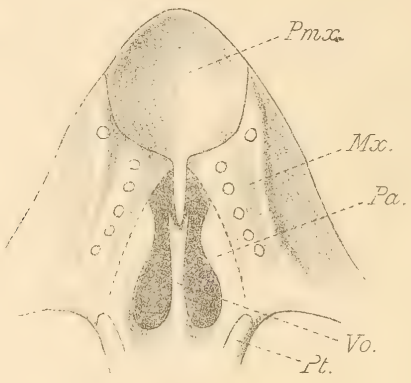

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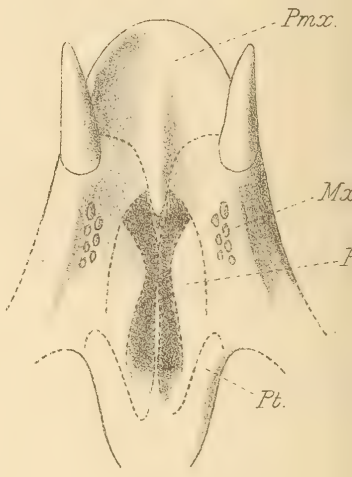

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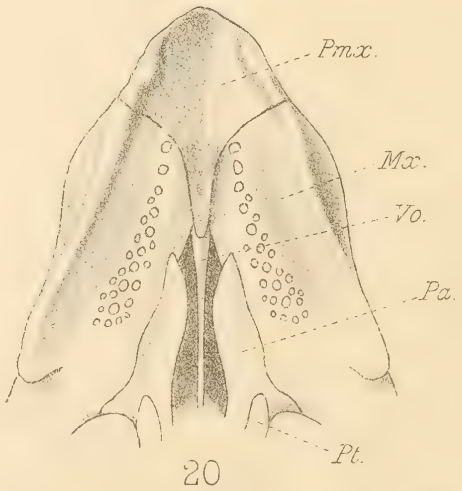

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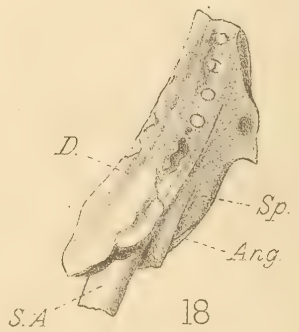

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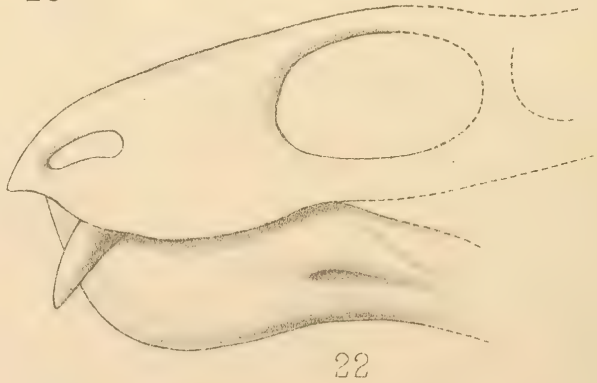

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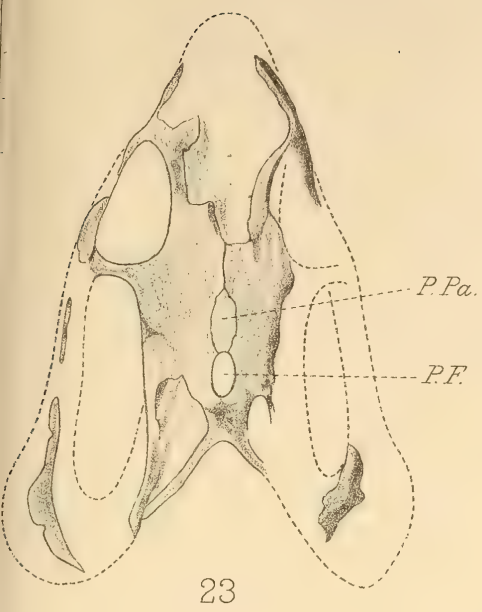
R. Broom del.

[illegible] ESOTERODON UNISERIES, *Owen*. Fig. 20 ENDOTHIODON BATHYSTOMA *Owen*.
[illegible] CRYPTOCYNODON SIMUS, *Seeley*. Fig. 21-22 PRODICYNODON PEARSTONENSIS, *Broom*.



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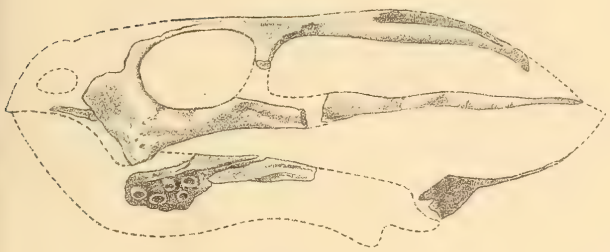

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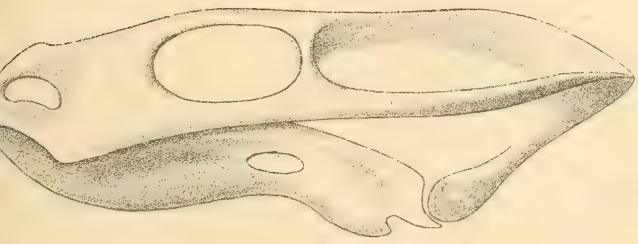

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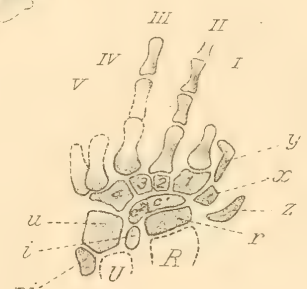

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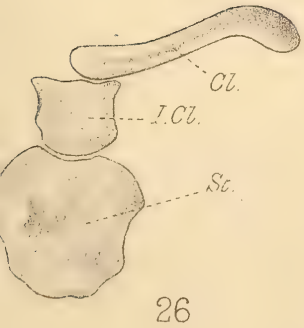

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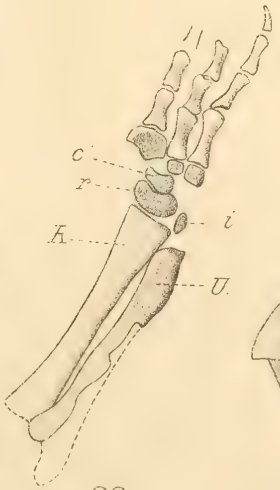

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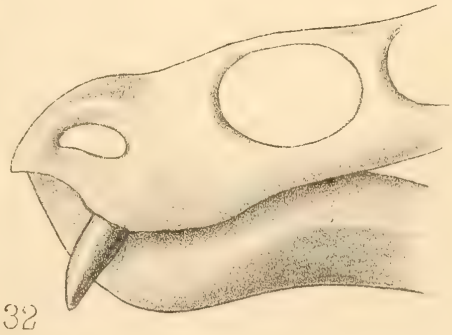

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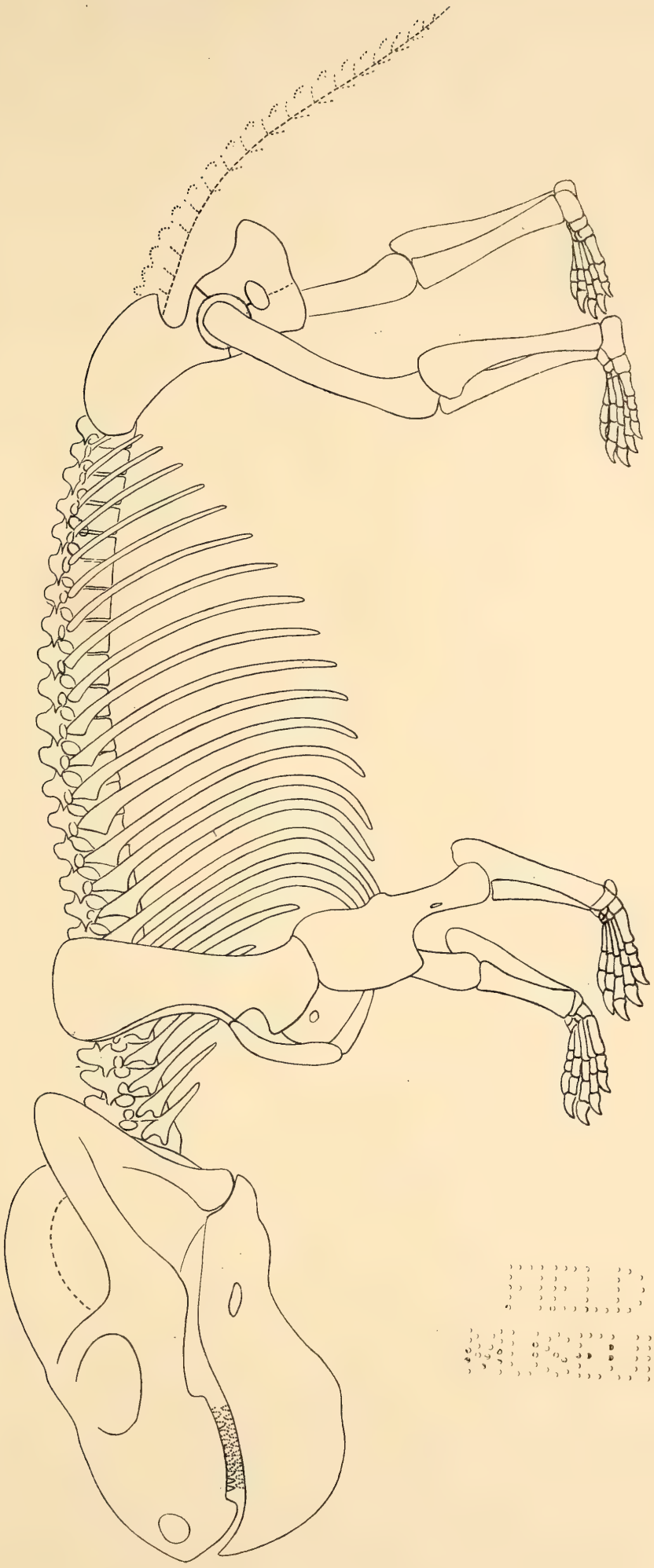
West, Newman lith. London.

FIG. 23-24 OPISTHOCTENODON BRACHYOPS, *Broom.* FIG. 31 CHELYOPOSAURUS WILLIAMSI, *Broom*
FIG. 25-30 OPISTHOCTENODON AGILIS, *Broom.* FIG. 32 PRISTERODON MACKAYI, *Huxley*



RESTORATION OF ENDOTHIODON BATHYSTOMA, *Owen. About 1/7 nat. size.*

R. Broom del.

West, Newman lith. London.

CATALOGUE OF PRINTED BOOKS, PAPERS AND MAPS RELATING TO THE GEOLOGY AND MINERALOGY OF SOUTH AFRICA, TO DECEMBER 31, 1904.

By *Miss* M. Wilman, South African Museum, Cape Town.

In these pages an attempt is made to bring together the titles of all contributions to the geology and mineralogy of South Africa. In addition a few papers are included which deal mainly with the geology of other lands, but have some reference to that of South Africa, and are therefore of interest to South African geologists.

Many of these works are of no scientific value, but are included because they are the only records that remain of the early workers. Others, again, find a place here solely because the references to them in the earlier lists are obscure, and it is thought that the full reference often describes the paper sufficiently to act as a warning to other explorers in the mazes of South African so-called *geological* literature.

A few text-books only are noticed that are of special interest, and no attempt has been made to include them all.

Much difficulty was experienced in making this catalogue, owing to the fact that the books which it was necessary to consult are scattered through so many libraries, that it was impossible for any one person to see them all. A great deal of valuable help has however been given by friends, and by others on whom I have no claim, and I have pleasure in thanking them for their very great kindness.

To mention them all by name would be an impossibility here, but some there are upon whose good nature specially large demands have been made.

Dr. G. S. Corstorphine and Admiral Maclear have sacrificed many a valuable hour to this list.

Mr. Walcot Gibson, of the Geological Survey of England, and Mr. J. V. Zelízko, of the Kaiserlich-Königliche Geologische Reichsanstalt, Vienna, have very kindly given their services, and it is almost impossible to say how much this catalogue owes to them for the time which they have spent, and the immense pains which they have taken in verifying references and in adding to the number of them.

To the compilers of the earlier book-lists and bibliographies, and to the custodians of the libraries which I have been allowed to use, my thanks are also due.

The abbreviations used are, in most cases, those adopted for the International Catalogue of Scientific Literature.

M. WILMAN.

CAPE TOWN,
December, 1904.

I

GENERAL

Abel, Clarke. Narrative of a journey in the interior of China, and of a voyage to and from that country in the years 1816 and 1817; containing an account of the most interesting transactions of Lord Amherst's embassy to the court of Pekin, and observations on the countries which it visited. [Geological appearances at the Cape of Good Hope, 285–312.]
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